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Take this *Supplement* to Las Vegas and use it as a guide to the Free Communications Sessions

Dear NATA Members and Friends:

We are pleased to present the annual *Supplement* to the *Journal of Athletic Training*. This Supplement contains abstracts presented at the 2013 NATA Annual Meeting & Clinical Symposia in Las Vegas, Nevada as part of the NATA Foundation Free Communications Program.

The Free Communications Program provides certified athletic trainers, students and other healthcare providers an opportunity to present and learn about the latest in athletic training research. Research is presented in oral and poster formats and includes general research, NATA Foundation-funded research, thematic posters, clinical case reports and our Student Exchange program posters. Abstracts of the research are printed here in the order of presentation at the NATA Annual Meeting in Las Vegas for your convenience. Free Communications presentations represent a wide range of research and clinical interests. In addition, the Clinical Case Reports sessions allow you to test your clinical assessment skills. We encourage you to attend these presentations.

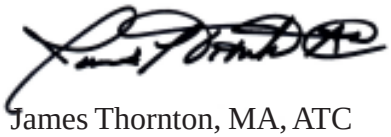
We also urge you to attend the sessions featuring research funded by the NATA Foundation. The NATA Foundation funds research and a variety of educational programs, including summits on issues critical to athletic training, as well as annual scholarships to undergraduate and graduate students of athletic training.

Support from NATA members, corporations, and other affiliated groups make this supplement and all of our programs possible. Please note projects funded by the NATA Foundation and by the generous contributions of our donors are specified in this Supplement. To make an investment in the future of the profession, please contact us today at 800-TRY-NATA, extension 147.

NATA and the NATA Foundation are pleased to offer this supplement as a service to NATA members. We hope that it provides theoretical and practical information you can use to improve your effectiveness as a certified athletic trainer. Thank you for your support!

Sincerely,

Mark A. Hoffman, PhD, ATC
President, NATA Research & Education Foundation



James Thornton, MA, ATC
President, NATA

Dear Colleagues:

On behalf of the National Athletic Trainers' Association Research & Education Foundation and the Free Communications Sub-Committee, we would like to thank all the authors who submitted abstracts to the Free Communications Program. We are happy to report a record number of submissions again this year with the total exceeding 500 Peer Reviewed and Student Exchange Track submissions, combined. We are excited about this year's Free Communications Program as we believe it contains an exciting mix of both high caliber research reports and clinical case studies. Please keep in mind that we consider oral and poster presentations to be equal in terms of caliber and encourage clinicians and researchers to attend both oral and posters sessions.

We would also like to take this opportunity to extend a special thanks to the all of the NATA Foundation staff and especially Patsy Brown; and Rachael Oats, CAE whose attention to detail and dedication makes the Free Communications Program possible. Additionally, many individuals have worked very hard to review submissions, schedule presentations, and produce this *Supplement to the Journal of Athletic Training*. Therefore, we would like to thank and recognize the efforts of the Free Communications Committee including: Joe Hart, PhD, ATC; Lisa Jutte, PhD, ATC; Tom Kaminski, EdD, ATC; Stephanie Mazerolle, PhD, ATC; Melanie McGrath, PhD, ATC; Sara Nottingham, EdD, ATC; Darin Padua, PhD, ATC; Brian Ragan, PhD, ATC; Stephen Straub, PhD, ATC; Charles Thigpen, PhD, ATC, PT; Kavin Tsang, PhD, ATC and Susan Walker-Yeargin, PhD, ATC for their long hours of abstract reviews and preparation for the Free Communications programming. Lastly, we wish to thank Leslie Neistadt and the staff at the editorial office of the *Journal of Athletic Training* for making the *Supplement* possible.

As we move forward, we continually try to improve and make the review process more transparent. Our goal is to be as inclusive as possible while maintaining the high level of scholarship that readers expect of the *Journal of Athletic Training*. We appreciate the feedback we have received from authors, and suggestions are always welcomed and discussed in committee meetings to further improve the process.

We look forward to seeing you in Las Vegas. Please take the opportunity to attend the Free Communications evidenced-based forums, peer reviewed oral and poster sessions, and the student exchange poster presentations. Please note that projects funded by the NATA Research & Education Foundation are specified in this *Supplement.* Finally, if you have the opportunity, please offer your thanks to those recognized above.

Sincerely,

Jennifer E. Earl-Boehm, PhD, ATC

Vice Chair for Free Communications,
NATA Research & Education Foundation Research Committee

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The New Investigator Award Presented in Honor of Freddie H. Fu, MD

Timothy Butterfield, PhD, ATC
University of Kentucky

When Tim Butterfield injured his knee herding cattle at a dairy farm in 1984, he could not have predicted he would one day have his own laboratory, designing new equipment and methods to further athletic training research and practice. Like many athletic trainers, Butterfield only discovered the profession after his injury.

"I didn't realize what sports medicine was," he says, though he was no stranger to medicine of another sort. Butterfield grew up on a dairy farm and worked for veterinarians since he was 12 years old. His career path changed when his injury led him to Pete Farrell, the head athletic trainer at Potsdam State. Eventually, Butterfield would take over that position from the retiring Farrell.

First, however, he had to change direction. Although he was nearly ready to graduate with his biology degree, he delayed graduation to meet the necessary undergraduate requirements to study athletic training as a graduate student. After 2 years of study and an internship at Messiah College, he attended Old Dominion University for his master's while serving as the head athletic trainer at Virginia Wesleyan College.

Butterfield was originally to be 1 of 2 athletic trainers at the school, but when the second person didn't show, Marty Bradley, the athletic trainer at Old Dominion, told him to go at it alone. Butterfield sees it as the "best experience I could have gotten, to see what being a head athletic trainer was like. I've always loved responsibility falling on my shoulders," he remembers, "and being given enough of a leash or rope to hang myself or do well."

After working as the head football athletic trainer at Mansfield University for 5 years, he was offered the position that inspired him to study athletic training at Potsdam State. Not only did he return to his alma mater, but he also began teaching for the first time. "I liked the opportunity to see a difference in students over time," he says.

After 3 years at Potsdam, Butterfield moved to the University of Calgary to earn his doctorate and then to The Ohio State University to research and teach. There, he found himself specializing in muscle. "Muscle, unlike other tissues, is irritable and activatable, changes its function and form, and does many things we don't understand to this day."

Butterfield's interest in muscle manifests in his research, which focuses on the effectiveness of massage. He saw many teams using massage therapy in the athletic training room of the 1996 Atlanta Olympics, despite little actual evidence justifying its use. "What we're doing now is finding that different loads, durations, frequencies all have a huge impact and difference on how the muscle cell signals to stimulate inflammation, damage, and repair."

He got another "long piece of rope to work with" when Carl Mattacola and Tim Uhl invited him to the University of Kentucky. He was given an empty space on the 4th floor, some start-up money, and free reign. "Five and a half years later, we're still doing this," he says. The lab has developed, among other projects, bottle nipples for testing premature infant tongue strength, novel dynamometers, massage devices, and speech therapy tools.

Currently, Butterfield is researching manipulation of the immune response after exercise and delaying atrophy though massage. "If we keep finding novel data, we'll keep writing the grants. I would like to get into some aging work, because we're all getting older. And the more active we can stay, the more healthy we'll be."

In addition to Farrell and his family, Butterfield thanks Sandy Bush, ATC; Robert H. Shank, EdD, ATC, EMT-B; Marty Bradley, MS, ATC; Terry Zablocki, ATC, EMT; Scott Johnson, MA, ATC; Thomas Best, MD, PhD; and Walter Herzog, PhD.

Freddie H. Fu, MD

Dr. Freddie H. Fu, a longtime advocate of certified athletic trainers, is a well-respected physician whose work in sports medicine has earned repeated honors.

The 1996 winner of the NATA President's Challenge Award, Dr. Fu is the David Silver Professor of Orthopaedic Surgery and Chairman of the Department of Orthopedic Surgery at the University of Pittsburgh School of Medicine and University of Pittsburgh Medical Center.

He has been the head team physician for the University of Pittsburgh Department of Athletics since 1986. He also was instrumental in establishing the Sports and Preventive Medicine Institute in 1985. Under his leadership, the facility – now called the UPMC Center for Sports Medicine – has grown into the region's largest, most comprehensive sports medicine center, regarded among the best in the country.

Dr. Fu holds secondary appointments as Professor of Physical Therapy and Health, Physical and Recreation Education. He was awarded an honorary doctorate of science degree from Point Park University and an honorary doctorate of public service from Chatham College.

Known worldwide for his pioneering surgical techniques to treat sports-related injuries to the knee and shoulder and his extensive research in the biomechanics of such injuries, Dr. Fu performs surgery at UPMC and sees patients at the UPMC Center for Sports Medicine. He also directs the University of Pittsburgh's Sports Medicine Fellows Society.

Dr. Fu is the editor of 26 major orthopedic textbooks and author of 75 book chapters on managing sports injuries. He has authored or co-authored 180 peer-reviewed articles and has given more than 600 national and international presentations.

Former president of the Pennsylvania Orthopaedic Society, he is a member of 40 other professional and academic medical organizations including the prestigious Herodicus Society. Currently he serves as Second Vice President of the International Society of Arthroscopy, Knee Surgery and Orthopedic Sports Medicine and will assume the presidency of ISAKOS in 2009. He is also on the Board of the American Orthopaedic Society for Sports Medicine and the Orthopaedic Research and Education Foundation. Dr. Fu has served as chairman of the board and executive medical director of the UPMC/City of Pittsburgh Marathon, company physician and board member for the Pittsburgh Ballet Theatre, and team physician for Mt. Lebanon High School.

The Doctoral Dissertation Award Presented in Honor of David H. Perrin, PhD, ATC Sponsored by Friends of Dr. Perrin

Dorice Hankemeier, PhD, ATC
Ball State University

Many high school students ignore their injuries until they're forgotten, but a young Dorice Hankemeier asked herself, "why is this taking so long to get better?" Nearing the end of her time in high school, Hankemeier decided to seek more information to better understand her experience with injury and recovery. She graduated from Central College (Pella, IA) in 1997 and then went on to earn a MSEd from Old Dominion University in 2003, practicing in various clinical athletic training positions throughout. In 2008, she began her doctoral program at Old Dominion graduating in 2011 with a cognate in curriculum and instruction.

Her research looks empirically at how athletic training students are being taught evidence-based practice and how they are using those lessons. "We're teaching our students these things, but," she asks, "clinically, how are they implementing them?" Her dissertation follows the tiered, Scandinavian model, consisting of 3 parts. The first, "Approved Clinical Instructors' Perspectives on Evidence-Based Practice Implementation Strategies for Students," was published in the JAT in 2011. The second and third projects, "Perceptions of Approved Clinical Instructors: Barriers in the Implementation of Evidence-Based Practice" and " Use of Evidence-Based Practice Among Athletic Training Educators, Clinicians, and Students, Part 1: Perceived Importance, Knowledge, and Confidence" were published recently in *JAT*. "When I was an undergraduate student, I never would have thought about going on to pursue my doctorate. I was really focused on the clinical aspect of athletic training, but as I progressed through my master's degree I became more interested in teaching and the educational component of athletic training."

Currently teaching and researching at Ball State in Muncie, IN, Hankemeier continues to strive for more and recalls that her "mentors saw in me that I could be successful in AT and always pushed me to get better." Today, she is "always looking for a new way of doing things and not just settling for where I was." With her colleagues, Hankemeier received an NATA program grant to develop free, online evidence-based practice modules; 15 are now available to the membership on the NATA Web site. Hankemeier sees long-reaching effects of paired research and recommendations. "I think we're just scratching the surface in some of the areas of outcomes assessment of athletic training programs which will become even more critical as we continue to move athletic training education forward," as will looking at how athletic trainers fit into the interprofessional team of health care.

"We need the data first," she says, but predicts a need for "global assessment" of athletic training education that goes beyond comparing BOCpassing rates. Although she hopes her research will help the athletic training profession continue to develop, she also strives to directly inspire her own students and "lead by example, not taking everything at face value but encouraging students to become critical thinkers."

Hankemeier thanks her undergraduate mentors John Roslien, ATC; Leslie Duinink, ATC; Pam Richards, EdD, for instilling a passion for the profession and challenging her to reach higher; Bonnie Van Lunen, PhD, ATC, for being a strong professional mentor and continually pushing her to new heights and areas of interest; friends Sarah Manspeaker, PhD, ATC; Cailee McCarty, PhD, ATC; and Stacey Gaven, PhD, ATC, for being strong supporters of her research; and her parents, Marv and Sara Hankemeier, who instilled the value of education and showed her what working hard truly meant.

David H. Perrin, PhD, ATC, FNATA, FACSM

David H. Perrin, PhD, ATC, is a respected researcher, educator, mentor and friend of athletic training. This 2003 NATA Hall of Fame inductee is a noted pioneer of terminal degrees in sports medicine, and his dedication to athletic training is making an impact on the profession's development even today.

Serving as editor-in-chief of the *Journal of Athletic Training* and founding editor of the *Journal of Sport Rehabilitation* are only two of Dr. Perrin's significant achievements. Others include being awarded NATA's Sayers "Bud" Miller Distinguished Educator Award in 1996, Most Distinguished Athletic Trainer Award in 1998, and All-University Outstanding Teaching Awards from the University of Virginia in 1997 and 1998.

Dr. Perrin has built research education programs at the undergraduate, master's, and doctoral levels and has fully dedicated himself to mentoring and developing future scholars. Dr. Perrin makes every effort to maximize his students' potential by offering sound advice and helping them make the most of their educational programs. Many of his students have gone on to bright careers in the profession, as researchers, program directors, clinical supervisors, and award-winning scholars.

Dr. Perrin continues to mentor students and serve as a leader in the profession. He is provost at University of North Carolina at Greensboro. He oversees five academic departments, nearly 75 faculty members and more than 1200 students. The school's Ph.D. program in the Department of Exercise and Sport Science has been recognized as one of the country's best programs. Dr. Perrin remains involved in the profession by teaching a class and advising doctoral students who are certified athletic trainers. He also continues to write in athletic training and has recently published three books.

The NATA Foundation Doctoral Dissertation Award, presented in honor of David H. Perrin, recognizes outstanding doctoral student research and is a fitting tribute to a man who has dedicated the duration of his career to mentoring and developing future scholars.

Cold Shower As A Treatment For Exercise-Induced Hyperthermia

Buening BJ, McDermott BP, Bonacci JB, Ganio MS, Kavouras SA, Adams JD, Matthews A, Tucker MA: University of Arkansas, Fayetteville, AR

Context: Exertional heat illnesses are common in individuals exercising in the heat. Exertional heat stroke, although not as common as heat exhaustion, is the most severe heat illness. Without rapid and effective treatment, exertional heat stroke can be fatal. Clinicians sometimes struggle with the feasibility of accessible cold-water immersion (CWI). Experts have recommended the use of a cold shower (CSH) when CWI is not feasible. **Objective:** Evaluate the efficacy of whole-body cooling when hyperthermic participants are cooled utilizing continual dousing with CSH. **Design:** Randomized, counter-balanced controlled study. **Setting:** Human performance laboratory (33.4 ± 0.9° C; 26.3 ± 3.2%RH). **Patients or Other Participants:** 17 participants (175.2 ± 6.9cm, 70.4 ± 8.7kg, age range: 19-35yrs.) volunteered. **Interventions:** Participants exercised volitionally for a maximum of 90min in a controlled environment on 2 separate occasions. Exercise mode, duration, intensity and fluid consumption were matched between trials. Following exercise, participants received either CSH (water temperature: 20.8 ± 0.80°C) while seated or sat in a chair (CON) for 15min. All data was collected in the same environmentally controlled room. **Main Outcome Variables**: Rectal temperature (T_{re}) and heart rate (HR) were recorded every minute during treatment. Thirst and thermal perception, rating of perceived exertion, and muscle pain sensation were taken every 5min during treatment. Repeated measures ANOVAs were utilized to compare differences between trials. Bonferroni corrections were utilized when appropriate. Alpha was set to d" 0.05. **Results:** T_{re} (CSH: 39.09 ± 0.25°C; CON: 39.04 ± 0.38°C; *P*=.927) and HR (CSH: 174 ± 17bpm; CON: 173 ± 19bpm; *P*=.967) were not different throughout exercise for CSH and CON trials. Thirst (*P*=.600), thermal (*P*=.694), perceived exertion (*P*=.637) and muscle pain (*P*=.307) during exercise were similar between trials. Both T_{re} and HR significantly decreased over time during rest, regardless of treatment (*P*d".001). However, decreases in T_{re} (*P*=.278) and HR (*P*=.236) over time were not significantly different between CSH and CON. However, overall cooling rate for CSH was 0.069°C·min^{-1} (range: 0.02 – 0.14°C·min^{-1}) and was significantly faster than during CON (0.047 ± 0.02°C·min^{-1}; range: 0.013 – 0.081°C·min^{-1}; *P*=.031). Overall, HR decreased to a greater extent during CSH (45 ± 20bpm) compared to CON (27 ± 20bpm; *P*=.002). Thirst (*P*=.005) and thermal perception (*P*<.001) were reduced to a greater extent with CSH compared to CON following exercise. **Conclusions:** CSH, despite perceptual benefits, is not clinically supported for the treatment of exercise-induced hyperthermia. It could take approximately 2-5 times as long to cool a hyperthermic victim with CSH compared to previous CWI data. Clinicians should continue to utilize CWI for exertional heat stroke, and should make every effort to have this available for the rapid treatment of patients when environmental conditions increase risk of heat illness.

Validation Of The Ottawa Ankle Rules For Acute Foot And Ankle Injuries Over Time

Gray KA, Ragan BG, Starkey C: Ohio University, Athens, OH

Context: The original and Modified Ottawa Ankle Rules (MOAR) were developed as clinical decision rules (CDRs) for the emergency department setting to determine the need for radiographs following foot or ankle injury. However, these CDRs have not been validated as an immediate sport-related clinical evaluation tool. **Objective:** To test the validity of the MOAR when applied within 30 min following sport-related injury. **Design** Cross-sectional. **Setting**: NCAA I athletics, collegiate club sports, and high schools. **Patients or Other Participants:** Thirty-three data collectors were ATs working with intercollegiate (n = 10), college club sports (n = 2), and high school (n = 21) populations. Data were collected using a standardized instrument. Data collection occurred for 11 months during 2011-2012. **Interventions:** Following the initial and/or re-examination of an acute foot or ankle injury, the AT completed an inventory identifying the key MOAR diagnostic findings and clinical diagnosis. Once the patient was cleared for participation, a definitive diagnosis was made, or no further intervention was required, the data collector submitted the instruments to the research team. **Main Outcome Measures:** A 2x2 contingency table identified the number of true positive, true negative, false positive, and false negative findings. To assess the validity measures of diagnostic accuracy, positive predictive value (PPV), negative predictive value (NPV), sensitivity (Sn), specificity (Sp), positive likelihood ratio (LR+), and negative likelihood ratio (LR-) were calculated. **Results:** Eighty-four acute

examinations were performed within 30 min of the initial injury (mean time between the injury and examination was 6.0 ± 8.4 min). Thirty-three of the 84 (39.3%) examinations met the MOAR criteria, 5 (15.2%) were positive for a fracture. No fractures were reported in the 51 cases that did not meet the MOAR referral requirements. In all models examined the Sn =1.0, NPV = 1.0, and the LR- was zero. The overall all accuracy of the MOAR was .67, PPV = .15, Sp = .60, and LR+ = 2.86. Using only weight bearing status yielded an accuracy to .56, PPV = .12, Sp = .53, and LR+ = 2.14. Examining only the palpation predictor variables decreased accuracy to .35, PPV = .08, Sp = .30, and LR+ = 1.44. **Conclusions:** Negative findings on the MOAR accurately ruled out the need for radiographs, but positive findings are poorly predictive of the presence of a fracture. The pooled findings of palpation and weight-bearing status are better predictors than palpation or weight-bearing status alone. The absence of false negative findings lends further validity to the MOAR.

Anterior Cruciate Ligament Reconstruction Participants Exhibit Deficits In Quadriceps Strength And Up-Regulation Of Corticospinal Excitability

Clements AE, Lepley AS, Ericksen HM, Sohn DH, Levine JW, Gribble PA, Pietrosimone BG: University of Toledo, Toledo, OH

Context: Neuromuscular dysfunction of the quadriceps is a hallmark impairment following anterior cruciate ligament reconstruction (ACLr), which can include deficits in quadriceps strength and activation, contributed to by alterations in neural excitability. It is thought that traditional ACLr therapeutic exercise regimens will regain normal function of spinal-reflexive and corticospinal excitability pathways, yet little is known about how these neuromuscular outcomes are affected years following ACLr. Knowing how neuromuscular deficits are affected will provide evidence essential to the development of improved rehabilitation strategies for ACLr. **Objective:** Evaluate differences in quadriceps strength, activation, spinal-reflexive excitability and corticospinal excitability between ACLr individuals with high levels of self-reported dysfunction and healthy controls. **Design:** Case-control study. **Setting:** Research laboratory. **Patients or Other Participants:** Nine unilateral ACLr patients (2M/7F, 21.1±2.2years; 170.8±11.6cm, 74.6±20.7kg, 48.1±29.6 months post-surgery) were compared to twenty-two healthy controls (7M/15F, 23.0± 4.0years; 171.1±8.3cm, 71.1± 11.9 kg). All ACLr patients scored less than 85% on the International Knee Documentation Committee questionnaire (IKDC; 73.5±9.0). **Interventions:** Vastus medialis strength, voluntary activation, spinal-reflexive excitability and corticospinal excitability were tested in the injured limb of ACLr participants and in a randomly assigned limb of healthy controls. **Main Outcome Measures:** Quadriceps strength was assessed via maximal voluntary isometric contractions (MVIC) performed at 90° of knee flexion and normalized to body mass. Quadriceps activation was determined by using the central activation ratio (CAR) obtained through the burst superimposition technique. Quadriceps spinal-reflex excitability was assessed using maximal Hoffmann reflexes normalized to maximal muscle responses (H:M). Quadriceps corticospinal excitability was measured via motor evoked potentials (MEP) elicited at 120% of active motor threshold and normalized to maximal muscle responses. Independent t-tests were performed to identify differences between groups, and alpha was set *a priori* at $P \leq 0.05$. **Results:** ACLr participants demonstrated significantly less strength (ACLr MVIC: 2.32Nm/kg±0.72; Healthy MVIC: 3.19Nm/kg±1.1; $t_{29} = -2.17$, $p=0.03$) and higher corticospinal excitability (ACLr MEP: 0.051±0.044; Healthy MEP: 0.023±0.01; $t_{29} = 2.65$, $p=0.01$) compared to healthy controls. There were no differences between groups in activation (ACLr CAR: 0.88±0.12; Healthy CAR: 0.92±0.09; $t_{29} = -0.96$, $p=0.34$) or spinal-reflexive excitability (ACLr H:M: 0.24±0.16; Healthy H:M: 0.20±0.11; $t_{29} = 0.85$, $p=0.39$). **Conclusions:** ACLr participants with IKDC<85 had significantly less strength and higher corticospinal excitability than healthy controls; however, they did not differ from healthy participants in quadriceps activation or spinal-reflexive excitability. The up-regulation of corticospinal excitability in the ACLr group may be a post-injury mechanism to maximize quadriceps

activation, explaining similar activation levels between groups. However, corticospinal up-regulation alone may not be a sufficient strategy to develop or maintain quadriceps strength. Further research should identify what factors contribute to deficits in quadriceps strength, and which factors can be clinically modified to improve strength.

Patient, Injury, And Assessment Characteristics Of Sport-Related Concussions At Initial Evaluation: A Report From The Athletic Training Practice-Based Research Network

Kostishak N, Anderson B, Lam KC, Valovich McLeod TC: A. T. Still University, Mesa, AZ

Context: Most studies describing concussion assessment practices have used self-report surveys and have reported wide variation in practices. Understanding real-time concussion assessment practices, through a review of medical records, can provide a better understanding of the initial clinical presentation and subsequent management of the injury. **Objective**: To describe the patient, injury, and assessment characteristics of sport-related concussion at initial evaluation. **Design**: A retrospective analysis of electronic medical records (EMR). **Setting**: Athletic Training Practice-Based Research Network (AT-PBRN). **Patients or Other Participants**: 623 patients (392 male, 231 female, age=17.0±1.8 years) diagnosed with a concussion by an athletic trainer (AT). **Interventions**: Patient records from 57 AT-PBRN clinical practice sites between October 2009-October 2012 were reviewed. All records were completed by an AT utilizing a web-based EMR. Concussed patients were identified by concussion-specific diagnostic codes (ICD-9: 850.0, 850.5, 850.9). **Main Outcome Measures**: Frequencies and descriptive statistics were utilized to describe patient (sex, sport, age), injury (time of injury, mechanism of injury, initial treatment plan, loss of consciousness, presence of amnesia and the assessment of cranial nerve function, coordination, range of motion, and strength) and assessment (% of initial evaluation components completed by ATs) characteristics. **Results**: Generic injury demographic forms were completed for 623 concussions, with football accounting for 49.6% (n=309). Most occurred during an in-season game (49.4%, n=308) or practice (32.1%, n=200) and the primary mechanism of injury was contact (84.1%, n=524). The initial treatment plan included AT-initiated treatment (41.7%, n=260) and referral to the emergency department (5.0%, n=31), team physician (7.4%, n=46), family physician (13.2%, n=82), and for imaging (1.3%, n=8). A concussion-specific evaluation form was completed for 60.4% (n=376) of cases. Loss of consciousness was noted in 4.0% (n=25), post-traumatic amnesia in 8.3% (n=52), retrograde amnesia in 6.6% (n=41), and aphasia in 1.4% (n=9) of cases. Pupillary size (93.4%, n=351), response (93.9%, n=353), and movement (88.6%, n=333) were normal in most patients. Coordination was also normal in most patients, whether tested by the heel-to-knee (31.6%, n=119), finger-to-nose (66.0%, n=248) or Romberg (44.9%, n=168) test. Individual cranial nerves were normal in 85.9-90.7% (n=323-341) of cases. With respect to assessment practices, ATs did not assess pulse (75.3%, n=283), blood pressure (100%, n=376), coordination (26.3-64.6%, n=99-243), cranial nerves (8.5%, n=32), range of motion (9.3%, n=35), or strength (17.1%, n=64) for the indicated percentage of cases. **Conclusions**: As expected, many of the clinical tests performed during an initial concussion evaluation were normal, ruling out an intracranial injury. Appropriate documentation was lacking, evident by the difference in the number of concussions identified compared to completed evaluation forms. Furthermore, vitals, coordination, and cranial nerves were not tested at initial evaluation, which disregards best practices. Clinicians should improve documentation of concussion assessment to ensure best practices and liability protection.

Oculomotor Function In Collegiate Student-Athletes With A Previous History Of Sport-Related Concussion

Braun PA, Kaminski TW, Swanik CB, Knight CA: University of Delaware, Newark, DE

Context: Current clinical tools that diagnose and assess concussed athletes do not include a component for measuring oculomotor function. Researchers in optometry and neurology have shown that eye movement deficits in subjects with a history of acquired brain injury exist, but these measurements have not been implemented utilizing an athletic population, or a population with a history of sport-related concussion. **Objective:** The purpose of this study was to determine if sport-related concussion creates lasting deficits in oculomotor function and learning, as measured by the King-Devick (KD) Test. **Design:** Quasi-experimental, ex post facto. **Setting:** Athletic training research laboratory. **Patients or Other Participants:** Convenience sampling was utilized to evaluate oculomotor function in one hundred seventy NCAA Division-I collegiate athletes. Seventy-three (40 males, 33 females, age=19.7±1.3 yrs., height= 177.4±10.6 cm, mass= 79.0±17.2 kg) had a previous history of sport-related concussion (mean number of concussions =1.5±1.3, mean recovery time=8.6±12.9 days, time since most recent concussion=28.7±28.0 months). The remaining participants (45 males, 52 females, age=19.7± 1.3 yrs., height=175.6±10.2 cm, mass= 77.1±16.3 kg) had no previous history of head injury. **Interventions:** Objective measurements were obtained through the use of the KD Test which assesses the speed of rapid number naming to capture impairments in eye movement and is becoming a widely accepted tool for rapid sideline concussion screening. The test involves 3 separate cards each with a different series of numbers. In order to effectively study learning effects, a total of two test trials were completed. **Main Outcome Measures:** The total time (seconds) to complete the KD Test (all 3 cards) was compared between groups (control vs. experimental). The independent variable was the participants' history of concussion. The improvement time (learning effect) was also evaluated between the first and second trials across groups. Separate ANOVAs were used to compare means between the two groups for both total time and improvement time. **Results:** No significant differences existed between groups for oculomotor function ($F_{1,168}$=0.870, p=0.352) or learning effect ($F_{1,166}$=0.253, p=0.615). The control group revealed a mean completion time of 38.21±6.17s as compared to the experimental group mean time of 39.12±6.48s. Results from learning effect scores were very similar as well. The experimental group with no previous history of concussion posted a mean improvement time of 2.48±2.87s, while the previously concussed group had a mean improvement of 2.68±2.12s. **Conclusions:** The oculomotor nerve can be damaged following sport-related concussion, especially with rotational impacts. Evidence from this study however, suggests that no long-term deficits in oculomotor function or learning exist in the collegiate student-athlete population who has sustained concussions. These findings help to strengthen the current concussion definition with regard to the transient nature of the associated symptoms. Additional research involving acutely concussed athletes studied along a continuum of recovery is warranted.

Predictors Of Frontal Plane Knee Kinematics During A Single-Leg Squat Task In Females With Patellofemoral Pain

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Context: Decreased gluteal and thigh muscle strength has been suggested to contribute to altered frontal plane knee kinematics in individuals with patellofemoral pain (PFP). Strengthening of these muscles is often a component of PFP rehabilitation programs. However, there is little research investigating the association between gluteal and thigh muscle strength with frontal plane knee kinematics in those with PFP. **Objective:** To examine the association between frontal plane knee kinematics and strength of the gluteal and knee extensor musculature in those with PFP. **Design:** Cross-sectional regression. **Setting:** Research laboratory. Patients or Other Participants: Sixteen females with PFP participated in this study (Age=25.3±6.1 years; Height=164.5±8.5cm; Mass=61.4±11.1Kg). Participants with PFP had at least two months of anterior, lateral or retro patellar pain during walking, running, stair ascent or descent, squatting, and/or sitting for an extended period of time, no other lower extremity injuries within six months prior to the testing, and negative findings on examination of ligaments and menisci. Interventions: Knee abduction angle was assessed using a seven-camera infrared optical motion capture system while participants performed three separate single-leg squat (SLS) tasks at a standardized speed. Three separate maximum voluntary isometric contraction (MVIC) trials during hip abduction (HAB_{MVIC}), hip extension ($HEXT_{MVIC}$), hip external rotation (HER_{MVIC}), hip adduction, and knee extension ($KEXT_{MVIC}$) were assessed using a hand-held dynamometer. Main Outcome Measures: Knee abduction (KAB) angle at the time of maximal knee flexion was averaged across three separate SLS trials. Peak values were averaged across three trials for each MVIC measure. Separate Pearson product moment correlations were performed to identify the association between KAB angle and each MVIC measure. A backward stepwise multiple regression analysis was performed using those MVIC variables significantly associated with KAB to determine the association between the KAB angle and MVIC variables ($\tilde{}<0.05$). **Results:** We observed significant correlations between KAB angle with HAB_{MVIC} ($r=0.56$, $p=0.029$), and HER_{MVIC} ($r=0.548$, $p=0.034$), and a trend correlations with $HEXT_{MVIC}$ ($r=0.457$, $p=0.087$). Regression analysis revealed that both HAB_{MVIC} and HER_{MVIC} were predictive of KAB angle during the SLS in those with PFP ($R^2=0.44$, $p=0.032$). **Conclusion:** Based on these findings, the combination of HAB_{MVIC} and HER_{MVIC} predicted nearly half of the variability in KAB angle during the SLS in individuals with PFP. However, neither $HEXT_{MVIC}$ nor $KEXT_{MVIC}$ were associated with KAB. Less HAB_{MVIC} and HER_{MVIC} are associated with greater KAB angle. Increased KAB has been suggested to increase contact pressure at the patellofemoral joint, which leads to cause pain. These findings suggest that exercises focused on improving HAB_{MVIC} and HER_{MVIC} may be effective for decreasing KAB during functional tasks in PFP patients.

The Effects Of Two Ankle Destabilization Devices On Electromyography Measures During Walking In Patients With Chronic Ankle Instability

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Context: Individuals with chronic ankle instability (CAI) have been shown to have deficits in neuromuscular control and altered gait patterns. Ankle destabilization devices may improve neuromuscular control by increasing lower extremity muscle activation, which may improve ankle stability. **Objective:** To compare EMG activation of lower extremity muscles during walking gait while wearing 2 different ankle destabilization devices. **Design:** Crossover. **Setting:** Laboratory. **Patients or Other Participants:** Fifteen young adults with CAI (height=173±11cm mass=72±14kg age=23±4 sex=M:5 F:10) participated. **Intervention(s):** Surface EMG electrodes were placed over the anterior tibialis (AT), peroneus longus (PL), and lateral gastrocnemius (LG). Subjects walked shod, with an ankle destabilization device (ADD), and an ankle destabilization sandal (ADS) in random order. The protocol consisted of 30 seconds of treadmill walking at 4.83 km/h during each condition. Stance time was determined with foot switches. **Main Outcome Measures:** Normalized amplitudes (100ms pre- and 200ms post-initial contact) and time of onset activation relative to initial contact were analyzed for 9 steps. Muscle activation was determined for each muscle if the amplitude was 10 SD over the mean amplitude during quiet standing. A negative value for time of onset represents muscle activation prior to initial contact. Percent of activation was calculated as the proportion of the total time across the stride cycle that

the amplitude was greater than the previously described threshold. Each dependent variable was compared using a repeated measures ANOVA and post-hoc t-tests as appropriate. The level of significance was set a priori at Pd"0.05. **Results:** The pre-contact amplitudes of the PL and LG were significantly greater in the ADD (PL 0.34±0.18, p=0.003; LG 0.22±0.15 p=0.003) and ADS (PL 0.30±0.11, p=0.003; LG: 0.18±0.15, p=0.028) conditions when compared to shod (PL 0.20±0.10; LG 0.09±0.05). The post-contact amplitude of the AT was significantly lower in the ADD (2.17±1.95, p=0.031) and the ADS (2.24±2.14, p=0.015) conditions when compared to shod (3.02±2.92). The post-contact amplitude of the PL was significantly greater in the ADD (1.62±0.97, p=0.001) and the ADS (1.33±0.64, p<0.001) conditions when compared to shod (0.76±0.37). The AT was activated significantly later in the ADD (-0.23±0.13ms, p=0.003) and the ADS (-0.30±0.14ms, p=0.009) conditions when compared to shod (-0.36±0.17ms). The AT, PL and LG were activated significantly longer across the stride cycle in the ADD (AT 61.1±30.3%, p<0.028; PL 48.8±11.9%, p=0.001; LG 31.4 ±17.4%, p=0.05) condition, but only the AT and PL were higher in the ADS (AT 60.9±28.8%, p=0.001; PL 44.4±12.7%, p=0.005) condition when compared to shod (AT 53.1±26.7%; PL 36.0±10.3%; LG 21.1±12.2%). **Conclusions:** Both ankle destabilization devices caused substantial alterations in muscle activity during walking. The destabilization devices may be useful adjuncts for use in rehabilitation programs for CAI.

Instrumented Anterior Mobilization Of The Ankle Joint Increases Contralateral Somatosensory Cortex Activation In Healthy Subjects

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Context: Ankle joint loading and joint mobilization have been demonstrated to affect the nervous system at multiple levels, resulting in increased joint sensation and tied closely to the magnitude of motor responses. While previous research has quantified changes in peripheral afferent traffic as well as reflexive motor activity, it remains unknown whether activation can be measured in the somatosensory cortex during joint loading. This data would provide initial evidence regarding how sensory integration of joint loading is occurring in the central nervous system, even at minimal force levels such as those provided during joint mobilization. **Objective:** To investigate the effect of anterior joint mobilizations at the ankle joint on contralateral somatosensory cortex activity using electroencephalography (EEG). **Design:** Single group post-test only. **Setting:** University laboratory. **Patients or Other Participants:** Nine subjects (2 male, 7 female, 21.0±2.6yrs, 165.0±9.0cm, 62.2 ± 13.2kg) with no history of injury to the ankle joint participated in this study. All subjects were right leg dominant. **Interventions:** Subjects were fitted with an EEG cap following international standards (impedance<5k˜) and ask to lay supine on a treatment table as a modified ankle arthrometer was used to load the ankle from -30N to 125N. A total of 50 trials were performed on the dominant leg, with 5 seconds between each trial. Data was collected at 1000Hz. **Main Outcome Measures:** Event-related desynchronization (ERD, %) in upper Alpha Frequency (10-12Hz) was used to detect changes in maximal ERD amplitude from a period of baseline (BASE, -2000 to -1000 ms prior to loading), and the first 2000ms of load application (LOAD1=0 to 1000ms; LOAD2=1000 to 2000ms) for the CP3 electrode position, which represents the contralateral somatosensory area of the cortex. Bonferroni corrected T-tests were used to compare ERD changes between BASE, LOAD1 and LOAD2 conditions. **Results:** Ankle load causes a significant increase in ERD in the contralateral hemisphere from BASE (0.6±0.7%) to LOAD1 (36.8 ±16.6%, p<0.0001) as well as from BASE to LOAD2 (LOAD2 =33.4±15.2%, p<0.0001). No significant difference could be demonstrated between LOAD conditions. **Conclusions:** Anterior joint mobilization at the ankle increases upper Alpha ERD during the first 2000ms of joint loading and suggests an activation of the contralateral somato-sensory cortex while load is applied. This data is the first to detect alterations in cortical activity during in-vivo joint loading, and lends support to a significant role of the brain during ankle joint mobilizations, even at relatively small loads. This approach could improve our understanding of sensory integration that must occur between the sensation of injurious loads and the formation of a reflexive response. Future investigations using this methodology may target how somatosensory cortex activation is affected among pathologic populations, and across various treatments.

Long-Term Upper Extremity Motor Performance Following Concussion: A Preliminary Investigation

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Context: Sport related concussion has historically been viewed as a transient injury void of long term consequences. Emerging evidence however, suggests changes to gait and balance can persist years after symptoms resolution. Investigations into upper extremity motor performance have not been conducted. **Objective:** The purpose of this investigation is to evaluate for differences in upper extremity motor performance between previously concussed and unconcussed young adults. We hypothesize that the previously concussed participants will demonstrate impaired motor performance. **Design:** Cross-sectional study design. **Setting:** Research laboratory. **Patients or Other Participants:** A total of 27 young adults (20.6yrs, 71.6kg, 174.3cm) with (n=14; 20.1yrs, 72.3kg, 174.5cm, 2.0 concussions, 3.1years prior) and without (n=13; 21.1yrs, 70.7kg, 174.1cm) a history of diagnosed concussions volunteered for this investigation. Interventions: Each participant completed a single, 15 minute evaluation of upper extremity motor performance on the ULTrA Board. The evaluation consisted of unilateral and bilateral responses to lighted targets in the vertical and horizontal planes. **Main Outcome Measures:** The primary variables evaluated were average time between targets on all conditions; average times between horizontal targets for the right and left hands; average times between horizontal and vertical targets for the right and left hands. The average response times between targets were compared using independent samples t-tests and Cohen's d was calculated as a measure of effect size. Significance was noted when $p<0.05$. **Results:** Significantly slower responses (concussed vs controls) to the lighted targets were recorded by those with a previous concussion for the average time between targets on all conditions ($0.71s\pm0.10$ vs $0.63s\pm0.09$, $d=0.79$, $p=0.05$) and the average time between horizontal targets for the left hand ($0.60s\pm0.04$ vs $0.54s\pm0.07$, $d=0.91$, $p=0.03$). Non-significant differences with large effects sizes were seen for the average time between horizontal targets for the right hand ($0.62s\pm0.08$ vs $0.58s\pm0.05$, $d=.63$, $p=0.11$) and average times between horizontal and vertical targets for the right hand ($0.76s\pm0.06$ vs $0.71s\pm0.08$, $d=0.74$, $p=0.07$) and left hand ($0.74s\pm0.05$ vs $0.70s\pm0.08$, $d=0.68$, $p=0.09$). **Conclusions:** These data are the first to demonstrate long-term changes to motor performance in the upper extremity in those with a concussion history. These findings parallel previous work indicating lower extremity deficits in a similar cohort. How these deficits may manifest in later life is not clear, but the deficits to recognition and response to the lighted targets may have implications to sport performance. *This project was funded by the Rackham Graduate School and the National Athletic Trainers' Association – Research and Education Foundation*

Effects Of Exercise On Measures Of Cerebral Blood Flow Integrity Using The Brain Acoustic Monitor In Healthy Individuals

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Context: Standard assessment of concussion does not currently include measurements of physiological deficits, such as cerebral blood flow, immediately post-injury. A new device, the Brain Acoustic Monitor (BAM), is purported to detect cerebral blood flow changes that occur after mild traumatic brain injury through the amplification and comparison of sound waves created by cerebral arteries and a reference artery in a peripheral limb. Were clinicians to begin using this device in an athletic population as an assessment tool immediately following injury, it is necessary to examine what effect exercise has on the stability of BAM measures. **Objective:** To determine the effect of exercise on outcomes associated with the Brain Acoustic Monitor. **Design:** Repeated-measures pretest-posttest. **Setting:** Laboratory. **Participants:** 20 healthy, recreationally active individuals (10 males and 10 females; age: 23.4 ± 4.3years, height: 173.4 ± 10.9cm, mass: 69.1 ± 14.2kg) volunteered. **Interventions:** Ten 10-second BAM measurements were obtained every 15 minutes for one hour prior to and following (T1= immediate, T2 = 15min post; T3 = 30min post; T4 = 45min post, T5 = 60min post) completion of a 20 minute treadmill program. The treadmill program consisted of a 5 minute warm-up period and 15 minutes of sustained submaximal exercise. Subjects were asked to maintain a pace that would equate to a Borg Rating of Perceived Exertion of 14 out of 20. Speed was manipulated by the subject

to maintain this level of exertion. **Main Outcome Measures:** The outcome measures associated with the Brain Acoustic Monitor are left brain (LB) and right brain (RB) ratio and divergence (measured in voltage). Ratio is a measure of the positive to negative acoustic signal deflection given by the cerebral arteries. Divergence is the difference in component frequencies between the brain signal and the peripheral arterial reference. The three best measures taken at the time point immediately prior to exercise and at each time interval following (T1, T2, T3, T4, T5) were averaged and analyzed using a 4 separate 6-factor ANOVAs. **Results:** Pretest measures (3.75 ± 0.89V) of LB ratio were significantly greater than those obtained at T1 (2.74 ± 0.64V; t=3.65, p=0.002), T2 (3.03 ± 0.61V; t=2.52, p=0.021), and T3 (3.17 ± 0.60V; t=2.37, p=0.03). No other time points were significantly different for LB Ratio, RB Ratio ($F_{(5,15)}$=2.25, p=0.103), LB Divergence ($F_{(5,15)}$=1.65, p=0.208), or RB Divergence ($F_{(5,15)}$=0.609, p=0.70). **Conclusions**: These results indicate that minimal alteration in BAM measures of cerebral blood flow occurs following 20 minutes of aerobic exercise. Some change in LB ratio was seen but this change was not found in RB ratio measures. This suggests that during clinical use, a 30 to 45 minute waiting period may be indicated before accurate measurements of cerebral blood flow integrity can be obtained using the BAM.

Influence Of Cold Water Immersion On Recovery Of Elite Triathletes In The Ironman World Championships

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Context: Ironman Triathlons impose intense physiological stresses. Cold-water immersion has been debated to improve recovery, however, no study has examined its effect following an Ironman. **Objective:** Examine the impact of cold-water immersion on recovery following an Ironman Triathlon. **Design:** Observational field study. **Setting:** 2011 Ironman World Championships in Kona, Hawaii (28.9°C, 71% relative humidity). **Patients or Other Participants:** 33 subjects (n=22 males, 11 females) entered in the Ironman World Championships (Mean±SD: age= 40±11y; height=174.5±9.1cm; percent body fat=11.4±4.1%). **Interventions:** Ten minutes of cold-water immersion to the sternal notch (10.4±0.2°C) immediately upon race finish. Subjects were randomized post race into a control group (CON) or intervention group (CWI). Data collection occurred prior to (PRE), immediately post (POST), 16 hours (16h) and 40 hours (40h) post race. **Main Outcome Measures:** Myoglobin (MYO), creatine kinase (CK), interleukin-6 (IL6), cortisol (CORT), C-reactive protein (CRP) and delayed onset muscle soreness (DOMS). A two-way mixed model ANOVA examined differences across time and between groups. Pearson's bivariate correlations compared finishing time and percent of time spent during bike (%B) and run (%R) sections. Alpha level was set *a priori* at 0.05. Hedges' g effect sizes were calculated. **Results:** CWI group (n=12; height=175.8±6.4cm; percent body fat=11.3±4.7%; finish time (hr:min)=10:30±00:50h) was similar ($p>0.05$) to CON (n=21; height= 173.5±8.4cm; percent body fat=11.5±4.4%; finish time= 11:21±1:33h) except for age (CWI=34±11y vs CON=43±10y; $p=0.020$). There was no significant difference between CWI and CON for any variable across time (CK, MYO, IL6, CORT, CRP, DOMS). However, an overall effect of time occurred for all variables. CK, MYO, CRP, and DOMS were significantly elevated POST (637±298IU/L ($p<0.001$), 43±15nmol/L ($p<0.001$), 24.76± 15.24nmol/L ($p=0.025$), 76.8± 13.3mm ($p<0.001$), respectively) and remained elevated through 40h (706±559IU/L ($p<0.001$), 4±4nmol/L ($p=0.016$), 2.34±1.16mg/dL 222.86 ±110.48nmol/L ($p<0.001$), 63.2± 24.8mm ($p<0.001$), respectively). IL6 significantly increased POST 0.67±0.18pg/dl; ($p<0.001$) however, returned to similar PRE values at 40h (0.004±0.003pg/dL). CORT was significantly elevated at POST (3461±658nmol/L; ($p<0.001$). Moderate effect sizes occurred for MYO at 16h (0.40), while small effect sizes occurred at POST for CORT (-0.29), CK (0.28), and IL6 (-0.30). IL6 was correlated with finish time at 16h ($r=0.378$, $p=0.30$) and %B ($r=0.454$, $p=0.008$) at POST. %R was correlated with CK at 16h ($r=0.349$, p-0.047) and 40h ($r=0.365$, $p=0.37$). **Conclusions:** The Ironman resulted in significantly elevated muscle damage and inflammatory markers. No effect of CWI vs CON was observed within the examined time frame. However, indices for muscle damage and DOMS remained elevated through the 40h time point, therefore observation of potential effects of CWI on return to PRE values past 40h was not possible. IL6 and CORT returned to similar PRE values by 40h. Thus, one bout of CWI immediately following an ironman race did not affect markers of muscle damage or inflammation up to 40h post race compared to CON.

Thermoregulatory Responses In Triathletes During A Competitive Ironman Race In A Warm Environment

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Context: The unique stress of an Ironman triathlon involving a 2.4 mile swim, 112 mile bike, and 26.2 mile run leads to extreme yet variable physiological and biochemical stress. Thermoregulatory responses during ultra-endurance exercise are often limited to measurements before and after exercise, warranting further investigation of repeated monitoring of the thermoregulatory demands imposed on the body during this event. **Objective:** Observe the response of gastrointestinal temperature (T_{gi}) in triathletes during a full Ironman distance triathlon race. **Design:** Observational field study. **Setting:** 2012 Lake Placid Ironman Triathlon (WBGT= 22.1 ± 2.0°C). **Patients or Other Participants:** Ironman triathletes participating in the 2012 Lake Placid Ironman (n=27; age=39.9 ± 8.0y; height=174 ± 11cm; body mass=73.1 ± 9.6kg; body fat=15.13 ± 6.19%). **Interventions:** All participants took an ingestible temperature sensor the evening before the Ironman race. T_{gi} was recorded via handheld receiver before the race (PRE), during the swim-to-bike transition (T1), during the bike-to-run transition (T2), and immediately following the race (POST). Data were analyzed via one-way ANOVA and are presented as mean ± standard deviation. Additionally, a Pearson correlation was performed to examine the relationship between delta (POST-PRE) thermoregulatory response ($\tilde{}T_{gi}$) and finish time. Significance level was set *a priori* at $p<0.05$. **Main Outcome Measures:** T_{gi}, finish time. **Results:** Mean finish time was 790.26 ± 87.01min. Mean T_{gi} at PRE (n=27), T1 (n=16), T2 (n=25), and POST (n=27) were 37.39 ± 0.34°C, 38.06 ± 0.42°C, 38.27 ± 0.28°C, and 38.42 ± 0.55°C, respectively. T_{gi} was significantly higher from PRE to POST race (1.03 ± 0.6°C; $p<0.001$). Additionally, T_{gi} was significantly elevated at T1 and T2 compared to PRE ($p<0.001$), while T_{gi} was also significantly higher at POST compared to T1 ($p=0.037$). Pearson correlation revealed no significant interaction between $\tilde{}T_{gi}$ and finish time ($r= -0.17$, $p>0.05$) **Conclusions:** Ironman competitors are a unique cohort of athletes who are exposed to extreme physiological demands due to the ultra-endurance nature of their sport. In-race monitoring provided an enhanced understanding of the thermoregulatory response to the Ironman race. The Ironman event resulted in a significantly higher T_{gi} at all time points compared to pre-race measurements, while T_{gi} was not correlated to finish time. Additionally, likely due to the intense biomechanical nature and prolonged exposure to environmental conditions, the combined bike and run portions of the race resulted in a further increase in T_{gi}. However, despite being exposed to physical, environmental, nutritional, and biochemical stressors that resulted in mild hyperthermia, the participants were able to avoid a detrimental rise in T_{gi} and potential of a subsequent heat illness that is commonly seen in higher intensity exercise.

Body Temperature In Baseball Umpires Wearing Cooling Vests During Activity

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Context: Exertional heat illness remains a potential for those employed in environmental extremes. Baseball umpires have attempted external mechanisms to assist body temperature maintenance during activity. Previous research on preventive cooling vests (CV) and thermoregulation have focused on moderate to severe temperature differences at the modality-skin interface. **Objective:** Determine effectiveness of CV that creates a minor thermal gradient at the modality-skin interface on body temperature and thermal sensation responses in baseball umpires during work. **Design:** Observational field study. **Setting:** Single Arizona fall league baseball season (92.6 ± 3.5°F, 13 ± 7%RH). **Patients or Other Participants:** 12 baseball umpires (183.9 ± 6.5cm, 95.5 ± 9.6kg, 23.8 ± 4.7 % body fat) rotated coverage between 3 stadiums and voluntarily participated. **Interventions:** Participants were randomly assigned to wear a CV (HTFx, Inc., Melbourne, FL) that changes phase at 50°F or no vest (NV) under normal padding and uniform umpiring. Subjects took an ingestible thermistor to quantify gastro-intestinal temperature (T_{GI}) at least 5 hours prior to data collection. Umpires reported to a researcher located near a dugout every ½-inning for T_{GI} and thermal sensation assessment. Data collection included 20 total games and analysis was run on 18 plate umpire (PUM) and 48 field umpire (FUM) games.

Main Outcome Measures: T_{GI}, thermal sensation, and average increase in T_{GI} for every ½-inning. Repeated measures ANOVAs were used to analyze treatment differences. Independent t-tests were used to identify differences in average T_{GI} increases. Alpha was set *a priori* at d"0.05. **Results:** T_{GI} was significantly increased compared to pre-game at every time point after 1.5 innings in PUM (pd".042) and FUM (pd".001). T_{GI} was consistently lower, although not significantly (p=.469), with CV (100.40 ± 0.19°F) compared to NV (100.59 ± 0.19°F) in PUM. Similarly, FUM demonstrated non-significant T_{GI} differences (CV: 100.13 ± .12°F; NV: 100.27 ± 0.13°F; p=.428). On average, T_{GI} was 0.19°F and 0.14°F less with CV than NV for PUM and FUM, respectively. There was a significant attenuation in the average increase in T_{GI} in PUM with CV versus NV (p=.038), but not FUM (p=.236). Thermal sensation was significantly increased after 5.5 innings compared to pre-game in PUM (pd".025), and after 0.5 innings in FUM (pd".001). Thermal sensation was significantly decreased with CV in FUM (CV: 5.2 ± 0.1; NV: 5.6 ± 0.1;p=.032), but not PUM (CV: 5.1 ± 0.2; NV: 5.6 ± 0.2; p=.150), despite a larger mean difference (PUM: 0.5 vs. FUM: 0.4). **Conclusions:** CV provided favorable results in preventing a rise in T_{GI} in PUM. FUM demonstrated positive, but not significant advantages. Future research is warranted using CV on participants engaging in more intense exercise and with greater thermo-regulatory challenge to determine clinical applicability of CV.

Comparison Of Practice Versus Game Hydration Behaviors In Collegiate Women's Soccer

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Context: Time constraints during soccer games and team dynamics during practices provide challenging circumstances to optimize hydration strategies. Previous research has examined hydration behaviors in collegiate women's soccer players during preseason practices. However, behavior difference between practices and games has not yet been explored. **Objective:** To observe and compare hydration status and fluid intake during games and practices. **Design:** Observational crossover design. **Setting:** Outdoor soccer field during August environmental conditions. **Patients or Other Participants:** Ten (19±1yo, 171.6±4.3cm, 65.6±9.6kg) DI collegiate women's soccer players, representing a variety of positions. Participants attended an informational meeting and signed a consent form prior to participating. **Interventions:** The independent variable was playing activity with two levels- game and practice. Players participated in both conditions. Five practices and 3 games were observed within 10 days. For pre and post practices and games, players arrived to the locker room and provided a urine sample and a semi-nude weight, which calculated body mass loss(BML) and sweat rates(SR). To record fluid consumed during practice, each player was provided two fluid bottles, one containing a carbohydrate-electrolyte beverage (CEB) and one water. Playing/activity time was recorded for each player during games and for groups during practices via an activity log. Researchers did not intervene in any other manner. **Main Outcome Measures:** Dependent variables included practice/game activity time, volume consumed(L), SR(L/hr), urine specific gravity(U_{sg}) via clinical refractometer, urine color (U_{col}) via color chart, and BML(kg). One way ANOVA was conducted for fluid consumed, SR, and hydration status variables. Post hoc paired t-tests were conducted for hydration status variables. **Results:** Players consumed more fluids during games than practices(1.7±0.7L vs. 0.8±0.5L; $P<0.001$).Participants consumed more water during games than practices(1.1±0.7L vs.0.5±0.4L; $P<0.001$) as well as CEB (0.6±0.5L vs. 0.5±0.3L; P=0.79), respectively. SR were greater during games than practices(1.6±0.5L/hr vs. 0.8±0.3L/hr; $P<0.001$). Activity time was longer in practices than games(1.6±0.3hrs vs. 1.4±0.4hrs; $P=0.039$). Players arrived to games hydrated(1.014±0.007µG, 3±1) compared ($P<0.001$) to minimal dehydration for practices (1.020± 0.008µG, 4±1). BML during games and practices(0.7±1.0kg vs 0.6±0.7kg) were similar. Practice hydration status increased pre to post for U_{sg} (1.020±0.008 µG vs 1.022±0.012, P=0.336) and U_{col} (4±1vs 4±1; P=0.020;) respectively. Game hydration status also increased pre to post for U_{sg} (1.013±0.006 µG vs 1.024±0.008, P<0.001) and U_{col} (3±1vs 5±1; P<0.001) respectively. **Conclusions:** Despite time constraints during games, players employed hydration strategies that took advantage of the time, resulting in greater consumption of fluids compared to practice. Even with the significant consumption of fluids, the higher intensity of games resulted in higher sweat rates and fluid losses, ultimately eliciting greater changes in hydration status. Activity time was increased during practices, however break opportunities were anecdotally more frequent, and decreased fluid consumption was offset by lower sweat rates.

Individualized Rehydration Protocol Resulted In Greater Relative Fluid Replacement Than *Ad Libitum* Hydration During A 20-km Trail Race In The Heat

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Context: Proper hydration is imperative for athletes striving for peak physical performance and ideal physiological training responses. Although laboratory research has shown that hydration significantly affects an athlete's physical performance and physiological responses, an optimal method of fluid replacement in the field setting remains undefined. **Objective:** To investigate how two distinct hydration protocols affect physiological responses and performance during a 20-km trail running race. **Design:** Randomized, counter-balanced, crossover design. **Setting:** Field setting (trails) in a warm environment (Mean±SD: WBGT 28.3 ± 1.9°C) **Participants:** Well-trained male (*n*=8) and female (*n*=5) runners (39±1y; 175 ± 9cm; 67.5 ± 11.1kg; 13.4 ± 4.6% body fat) volunteered for study participation. **Intervention:** Participants completed two 20-km trail races (5 x 4-km loop) with 2 different hydration protocols: (1) *ad libitum* (AL) condition and (2) individualized rehydration (IR) condition. At nine water stations, AL participants drank as much fluid as they chose and IR participants drank a prescribed volume of water to replace their pre-determined, estimated sweat losses. Data were analyzed using repeated measures ANOVA (*post hoc* paired t-tests, significance at *P*d"0.05). **Main Outcome Measures:** Percent body mass (BM) loss, heart rate (HR), gastrointestinal temperature (T_{GI}), time, plasma volume (PV) shifts, urine osmolality (U_{osm}), and serum electrolytes. **Results:** HR and T_{GI} responses were similar between conditions. Subjects drank only 32 ± 13% of their water losses in AL and 66 ± 13% of their water losses in the IR trial (*P*<0.001). Concordantly, AL experienced greater BM losses (-2.6 ± 0.5%) compared to IR (-1.3 ± 0.5%; *P*<0.001). A relative hydration deficit in AL vs. IR hydrated participants was further corroborated by U_{osm} differences between pre- and post-race (-273 ± 146mOsm (AL) vs. -145 ± 215mOsm (IR), *P*=0.032), and changes in %PV in AL (-4.9 ± 5.5%) vs. IR (-1.0 ± 4.6%; *P*= 0.013). Pre- to post-race changes in serum electrolytes (Na^+ and Cl^-) were also greater in AL than IR (*P*<0.001). Overall race times between groups were similar. **Conclusions:** An individualized rehydration protocol replaced double the amount of fluid loss than *ad libitum* drinking during a 20-km trail race. Differences in fluid consumption negatively affected several hydration indices with AL compared to the IR protocol. Despite a clear, quantitative difference in hydration level, AL and IR did not differ in HR, T_{GI}, or race performance. While IR did not completely replace sweat losses, it is recommended that athletic trainers utilize individual sweat rates when designing fluid replacement protocols. A more accurate method of individualizing fluid intake prescription would likely result in greater than 66% replacement of body water loss and perhaps more favorable performance benefits in future studies.

Hydration Measures Of Division I Collegiate Female Soccer Goalkeepers And Field Players

Minton DM, Torres-McGehee TM, Yeargin SW, Rosehart S, Paper S, Whittington E, Sutton K, Emerson CC: University of South Carolina, Columbia, SC

Context: Much of the hydration research within competitive soccer has utilized male athletes; additionally, goalkeepers (GK) are often excluded from research studies. Although GK do not cover as much distance during practices as field players (FP), they are required to perform high intensity, short duration activities requiring strength, speed, and agility. **Objective:** To determine hydration measures among female GK and FP during 11 days of pre-season practice. **Design:** Observational cohort study. **Setting:** Practice facility of a Division I collegiate female soccer team in the Southeastern United States. **Patients or Other Participants:** Participants were 17 (3 GK and 14 FP) female collegiate soccer players (age = 19±1yrs, height = 168.2±5.9cm, and weight = 63.8±7.0kg.) Players represented all education levels and FP represented all positions. **Intervention(s):** All hydration measures were assessed for 11 days (14 practices) during pre-season training. Participants provided a urine sample and weighed pre- and post-practice. Urine was measured for urine specific gravity (U_{sg}) and urine color (U_{col}). Weight was measured semi-nude. Volume of fluid consumed (V_{fluid}) during activity was measured for each player by providing individualized water and carbo-hydrate-electrolyte beverage (CEB) bottles. Practice time was recorded for each practice, from the beginning of warm-up to the end of the cool-down session. Sweat rate (SR) was calculated by using change in body mass and V_{fluid}. **Main Outcome**

Measure(s): U_{sg}, U_{col}, percent change in body mass (%˜BM), SR, V_{fluid}, and practice time. Repeated measures ANOVAs were used to determine differences in all dependent variables between GK and FPs over the 14 practices. **Results:** GK practiced significantly more than FP (1.87±0.5hrs vs. 1.69±0.4hrs, P = 0.003). GK consumed similar V_{fluid} (total = 1.1±0.6L; water = 0.5±0.4L, CEB = 0.7±0.5L) compared to FP (total =1.1±0.6L; water = 0.7±0.6L, CEB = 0.6±0.4L). SR was also similar for both GK and FP (0.7±0.4L/hr and 0.8±0.5L/hr, respectively). There were no significant differences between GK and FP for %˜BM, U_{sg}, or U_{col}. Mean pre-practice U_{sg} = 1.020±0.001µG and did not significantly increase post-practice (1.021±0.002µG). Mean %˜BM = -0.5±0.5%. **Conclusion:** While GK practiced longer, they consumed similar amounts of fluid during practice and hydration measures were not significantly different than the FP. Overall, players reported euhydrated and maintained this status. An explanation for these results may be the continuous education and pre-season hydration measures (e.g., pre-post body mass measures) by the team's athletic trainer, potentially impacting our results and supporting the role of athletic trainers in hydration education. Despite differences in practice time, GK and FP are similar in SR and hydration measures during pre-season practice. Athletic trainers should be aware of these similarities to minimize risk of dehydration. Future research should examine female soccer players at different competitive levels and during the season.

Validity And Reliability Of Two Digital Refractometers To A Manual Refractometer And Urine Color

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Context: Monitoring athletes' urine specific gravity (U_{sg}) is recommended by the National Athletic Trainers' Association to prevent heat illness and improve performance. Refractometry is considered the gold standard for measuring U_{sg}; however, the use of manual refractometers can be time-consuming and subject to user error. Digital refractometers are time-efficient and reduce subjectivity, however limited research has examined the validity and reliability of digital refractometers and no studies have examined this in an athletic population. **Objective:** To determine the validity and reliability of two commonly used digital refractometer models to a manual refractometer (MAN) and urine color (U_{col}). **Design:** Descriptive study. **Setting:** Division I collegiate female soccer team practice facility. **Patients or Other Participants:** Participants were 26 female collegiate soccer players (19±1yrs, 168.6±3.0cm, 65.1± 8.6kg). **Intervention(s):** As part of a larger study, participants provided pre- and post-activity urine samples over 19 days (23 practices and 3 games). Urine was analyzed by a MAN, a "pen-like" digital refractometer requiring the prism to be dipped into the sample (DIP), and a second digital refractometer requiring ~3ml of sample to be pipetted on to the prism (PIP). U_{col} was assessed using a U_{col} chart. Calibration was ensured prior to each data flight for each instrument. **Main Outcome Measure(s):** U_{sg}, measured by MAN, DIP, and PIP, and U_{col}. Pearson r correlations were used to determine the relationship between each of the refractometer models and U_{col}. Bland-Altman analysis was used to determine mean estimation bias and direction and 95% limits of agreement among refractometers. **Results:** A total of 714 urine samples were utilized for comparisons. Mean U_{sg} for MAN = 1.021±0.008˜G, DIP = 1.020±0.007˜G, and PIP = 1.019±0.007˜G. Mean U_{col} = 5±2. Strong, significant, correlations were found between each of the refractometer models (MAN-DIP: r =0.98; MAN-PIP: r =0.97; and DIP-PIP: r =0.97; P<0.001). U_{col} was also significantly correlated, albeit moderately, to each of the refractometers (r =0.60, P<0.001). Bland-Altman analysis revealed a mean error of 0.001±0.002 ˜G for DIP and 0.002±0.002 ˜G for PIP. A greater percentage of samples with measurement error e"0.005˜G was found for PIP (61/741, 8.5%) than DIP (26/741, 3.6%). PIP and DIP both had a trend to underestimate U_{sg} compared to the MAN. Misclassification as euhydrated when the MAN indicated hypohydrated (defined as U_{sg} ≥1.021˜G) occurred more frequently with PIP samples (8.5%, 61/714) than DIP (5.0%, 36/714). **Conclusion:** DIP and PIP measurements of U_{sg} were similar to MAN, however tended to underestimate U_{sg} and were more likely to classify samples as euhydrated when MAN classified those samples as hypohydrated. Athletic trainers should be aware of potential error when using digital refractometers to monitor U_{sg}. Future research is needed to examine the validity of digital refractometers compared to plasma hydration measures.

Reoccurring Exertional Rhabdomyolysis In A Division II Collegiate Football Athlete: A Case Report

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Background: The purpose of this case report is to document the treatment and outcome of reoccurring exertional rhabdomyolysis in a 22-year-old male Division II collegiate football player (mass=92.9kg, height=180.3cm). The athlete first began experiencing symptoms when he was 15-years-old playing high school (sophomore) football. It was not until he was 18-years-old and began participating in collegiate football that his condition was diagnosed. During a strenuous preseason football practice, he began experiencing full body muscle cramping with a burning sensation in his abdomen. The athletic training staff treated the athlete for severe cramping using cold-water immersion and oral fluids. Unable to control the cramping, the athlete was transported via EMS to the emergency department (ED). Evaluated at the ED, diagnostic testing (CBC and urinalysis) were positive for abnormal values of Creatine (1.6^6 mg/dl), Creatine Kinase (9,277 U/L), Bilirubin (2.5 mg/dl), Aspartate Aminotransferase (122 U/L), and hematuria suggesting a diagnosis of exertional rhabdomyolysis. **Differential Diagnosis:** Dehydration, electrolyte imbalance, potassium deficiency, myalgia, inflammatory myositis, exertional heat-related illnesses. **Treatment:** The athlete was admitted to the hospital for 4-days where he received intravenous fluids (3-days) while undergoing additional CBC and urinalysis testing. Once his CK levels decreased to near normal (males=38-174 U/L), he was discharged. Due to the lack of standardized care for exertional rhabdomyolysis, the athlete was cleared to return to play by his family physician and team physician with an understanding that he would report any recognized symptoms upon initial development. Since this episode, he experienced six additional bouts of exertional rhabdomyolysis (over a 5-year period), two events, which occurred during preseason practices needing, advanced medical attention. Normally, the athlete was treated for dehydration, myalgia, and muscle cramping. Treatment included increased clear liquid intake, NSAIDS, and hot compresses until symptoms had subsided. The athlete was educated on his condition and possible outcomes if symptoms were left untreated. He continues to participate with physician clearance. **Uniqueness:** Exertional rhabdomyolysis is a common form of rhabdomyolysis, affecting individuals participating in novel and intense exercise to which they are unaccustomed. This athlete was not new to the sport and supposedly understood the sport's physical demands, but still experienced subsequent episodes while participating in collegiate football. Even with education and constant reminding, he managed to suffer two more episodes needing emergent medical care. Both episodes occurred during preseason where the athlete experienced periods of intense training. However, prior to being diagnosed and educated, he freely admitted he would have continued to exert himself further past his maximal threshold, which could have had fatal consequences. **Conclusions:** Athletic trainers are well trained in the management of musculoskeletal injuries, environmental illnesses, and in medical emergencies. However, exertional rhabdomyolysis, as presented in this case, may be a condition that commonly goes undiagnosed because of the commonality of symptoms experienced in other injuries and illnesses. Athletic trainers need to be aware of the clinical features of exertional rhabdomyolysis to ensure athletes are not undiagnosed as the clinical features often mimic those of muscle cramping and heat-related illnesses. Evaluating clinicians must perform a thorough history and focused exam, in addition to ordering a serum CK and urinalysis. In this clinical setting, a CK equal to or greater than five times normal or a urine dipstick testing positive for blood with no demonstrable red blood cells upon microscopic assessment confirms the diagnosis. A urine or serum myoglobin is more definitive when expeditiously available. After treatment for exertional rhabdomyolysis, athletic trainers and physicians must risk-stratify athletes for risk of recurrence, consider further testing, and make the decision on when, if, and under what conditions the athlete can safely return to play.

Free Communications, Oral Presentations: Clinical Assessment of Movement Dysfunctions

Tuesday, June 25, 2013, 12:45PM-2:00PM, Palm B; Moderator: Anh-Dung Nguyen, PhD, ATC

Investigation Of The Measurement Properties Of The Functional Movement Screen™ In High School Athletes

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Context: Functional movement is an essential component to any athletic activity. The Functional Movement Screen (FMS) consists of seven tests used to evaluate fundamental movement patterns. The reliability of the clinical scoring system has been published, however there is minimal research investigating the reliability of the research scoring criteria in high school athletes. **Objective**: To investigate the intra- and inter-rater reliability of the FMS research scoring criteria in high school athletes. **Design**: Inter- and Intra-rater reliability. **Setting**: Local high schools and outpatient physical therapy facilities. **Patients or Other Participants**: Convenience sample of 30 high school athletes (15 females, 15 males; age 15.8±1.4 years, height 181.4±39.1cm, mass 67.4±6.9kg). **Interventions**: Each subject completed the FMS while being videotaped from an anterior and lateral view. Tests included: deep squat (DS), hurdle step (HS), in-line lunge (ILL), shoulder mobility (SM), active straight leg raise (ALSR), trunk stability push-up (TSPU), and rotary stability (RS). Videos were imported and edited, prior to video scoring. The primary researcher scored both live and video versions on two separate occasions, with the secondary and tertiary researchers scoring videos only. It should be noted each researcher had various levels of training with the FMS, with wide individual experience. Descriptive statistics and ICC's were calculated for the FMS research scoring criteria, evaluating both the individual tests and total score. Reliability of the test scores was calculated using intra-class correlation coefficients [ICC, (2,1)]. **Main Outcome Measures**: The dependent variable was the research scoring criteria, including both individual test scores and the total score. **Results**: The intra-rater reliability of the FMS research scoring criteria total score was ICC=.83 The following tests demonstrated good reliability (ICC>.75): HS total, SM right, SM total, ASLR left, TSPU, RS left. Tests with ICC's below .75 included: DS, HS right, HS left, ILL right, ILL left, ILL total, SM left, ASLR right, ASLR total, RS right, and RS total. Inter-rater reliability of the research scoring total score was ICC=.87. Individual tests resulting in ICCs>.75, including: HS right, SM right, SM left, SM total, ASLR right, ASLR left, ASLR total, and TSPU. The following tests demonstrated poor-moderate reliability with ICCs <.75: DS, HS left, HS total, ILL right, ILL left, ILL total, RS right, RS left, and, RS total. **Conclusions**: The reliability of the research total score for both intra- and inter-rater reliability was good. However, the reliability of the individual test scores varied, indicating the need for more research assessing the degree of agreement between individual tests. It is recommended for clinicians to obtain appropriate training to improve the potential for increased reliability, especially of the individual tests. It also seems to be more advantageous to score the FMS live, which allows three-dimensional views of the tests.

Functional Measures And Body Mass Index As Predictors Of Lower Extremity Injury Among Collegiate Football Players

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Context: Researchers and clinicians often seek ways to predict and prevent lower extremity injury. The star excursion balance test (SEBT) and the Functional Movement Screen (FMS) have been suggested as tools for predicting acute lower extremity (LE) injury. However, the injury prediction capability of the SEBT and FMS for collegiate football athletes is not established. Body mass index (BMI) may be another potential predictor of injury, but has had little application among collegiate football athletes. By utilizing these screening tools, clinicians may be able to identify athletes at risk for LE injury and recommend proper preventative intervention strategies. **Objective:** To determine the capability of the SEBT, FMS and BMI to predict acute ankle and knee injury in collegiate football players. **Design:** Prospective cohort. **Setting:** Athletic training facility. **Patients or Other Participants:** One hundred eighty, NCAA Division I football players (19.79± 1.38 yrs;1.86±0.07m,102.29±18.92kg) volunteered to participate. **Interventions:** Prior to the 2010-2011 and 2011-2012 football seasons, participants completed a single session in which height and mass, the anterior reach of the SEBT (A-SEBT) and all seven stations of the FMS (deep squat, hurdle step, in-line lunge, shoulder mobility, active straight leg raise, trunk stability push-up, and rotary stability) were evaluated. **Main Outcome Measures:** Dynamic postural control was measured bilaterally using A-SEBT. The mean of three reaches (cm), expressed as a

percentage of the stance limb length (cm), was used. Each station of the FMS is scored on a 0-3 scale, with a total possible composite score of 21 points indicating a perfect performance. The lowest score of three attempts in each station was used to create the total score. BMI was calculated with the following equation: weight (kg)/[height (m)]^2. Certified Athletic Trainers tracked and reported traumatic ankle and knee injuries. After the competition season, athletes were placed in an injured (traumatic ankle or knee injury; n=33) or uninjured (n=147) group. Sensitivity and specificity were used to create positive and negative likelihood ratios, from which diagnostic odds ratios (DOR) were created separately for each outcome measure. **Results** For the A-SEBT, a normalized reach distance of 70.84% was associated with strong sensitivity (0.79) and moderate specificity (0.55), with a DOR of 4.63. For the FMS, a score of 15.5 was associated with low-moderate sensitivity (0.42) and strong specificity (0.74), with a DOR of 2.08. For BMI, a score of 28.97 was associated with moderate sensitivity (0.58) and specificity (0.63), with a DOR of 2.34. **Conclusions:** Specific SEBT, FMS and BMI measures suggested a LE injury was 2-5 times more likely to occur during the season. Clinicians and researchers should continue to examine what combination of screening measures are the most efficient to implement.

Functional Movement Screen And Beighton And Horan Joint Mobility Index Scores Between Levels Of Pubescence In Athletes

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Context: The pubertal growth spurt may cause alterations in joint flexibility, joint laxity, muscular strength, balance, and coordination, which could result in an increased incidence of musculoskeletal injuries. The Functional Movement Screen™ (FMS) and the Beighton and Horan Joint Mobility Index (BHJMI) may be good clinical tools to identify these changes that occur during adolescence. While the BHJMI has been shown to identify differences in joint laxity in the adolescent population, there is no evidence whether the FMS can identify such differences among children. **Objective**: To compare FMS and BHJMI scores between gender and pubertal maturation in 8-14 year old athletes. **Design**: Cross-Sectional. **Setting**: Various athletic facilities. **Participants**: Sixty-six youth athletes actively participating on an organized athletic team (29 females, 37 males, 11.45±1.98 years, 151.16±12.67cm, 41.90±12.86kg). Participants were categorized into three maturational categories [pre-pubescent (PRE), early-pubescent (PUB), post-pubescent (POST)] based on the Pubertal Maturation Observational Scale that was completed by the participants' parent or legal guardian prior to participation. **Interventions**: Participants performed each BHJMI test (9) once, each FMS task (7) a maximum of three times (highest score was documented as task score), and the three FMS clearing tests. If the clearing test was positive, zero was scored for the corresponding FMS task. The scores of each BHJMI test and FMS task were tabulated into composite scores. **Main Outcome Measures**: The dependent variables were BHJMI and FMS composite scores. The independent variables were maturation stage (3) and gender (2). Between and with-in group differences were calculated using separate 2x3 factorial ANOVAs (*P*d"0.05) for each dependent variable. In the presence of an interaction or main effect, Fisher's LSD post-hoc comparisons were calculated. A Spearman Rho (*r*) analysis of correlation was utilized to assess relationships between FMS and BHJMI composite scores. **Results**: There was a significant increase in FMS scores (*P*=0.032) but not BHJMI scores (PRE=2.69±0.40, PUB=1.96 ±0.40, POST=3.13±0.43, *P*=0.131) across pubertal stages. POST subjects (15.91±0.47) had significantly greater FMS scores (*P*=0.008) than the PRE subjects (14.28±0.44) and PUB subjects (14.55±0.44; *P*=0.039). No differences were identified between gender and FMS scores (males=15.16±0.38, females =14.67 ±0.35, *P*=0.351) or BHJMI scores (males=2.36±0.35, females= 2.83± 0.32**,** *P*=0.321). No significant interactions were found between gender and pubescence regarding the BHJMI composite scores (*P*=0.503) or FMS composite scores (*P*=0.216). There was no correlation between FMS composite scores and BHJMI composite scores (*P*=0.89) [r(s)=-0.017] **Conclusions**: Our results suggest that the FMS may be a good clinical tool for assessing musculoskeletal alterations that occur as a result of the pubertal growth spurt since it can discriminate between maturation stages whereas the BHJMI may not. A prospective extension of this study to include follow-up of injured participants appears worthwhile to determine if the FMS can suitably predict injury in the adolescent population.

Functional Movement Screen™ Differences Exist Between Male and Female Adolescent Athletes

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Context: Injury prevention and athletic performance are reliant upon integration of adequate mobility, stability, and neuromuscular control to produce fundamental movement patterns, including squatting and lunging. Several movement screens exist to assess the quality of functional movement and ultimately determine injury risk. The Functional Movement Screen™ (FMS) is a commonly used tool, and evidence suggests that athletes who score <14 points on the FMS are at increased risk for injury. However, there is minimal research investigating FMS score differences and injury risk between healthy male and female athletes. **Objective:** To investigate sex differences in FMS individual test and total scores of healthy adolescent athletes. **Design**: Cross-sectional. **Patients or Other Participants:** Sixty healthy adolescent athletes (Male=31, age=16.0±1.1 yrs, height=177.1±8.1 cm, weight=75.1±11.0 kg; Female =29, age=15.9±1.3 yrs, height= 166.5±7.8 cm, weight= 61.8 ±7.4 kg) of convenience were tested. **Interventions:** Participants performed the FMS, which comprises 7 functional movement tests, including: deep squat, hurdle step, in-line lunge, shoulder mobility, active straight leg raise, trunk stability push up, rotary stability and 3 clearance tests. **Main Outcome Measures:** The dependent variables were FMS individual test scores and total score for composite (individual test score range=0-3 pts, total=21pts) and research (individual test score range=0-8, 0-12, 0-18, or 0-20 pts, total=100 pts) scoring methods. Lower scores indicate functional movement deficits and increased injury risk. Mann-Whitney U tests were used to determine sex differences in individual and total composite and research scores. **Results**: Females scored significantly lower on the following individual FMS tests: hurdle step (Composite: females=0.2±0.4 pts vs. males= 0.45±0.5 pts, P=0.046), in-line lunge (Composite: females=2.2±0.7 pts vs. males=2.6±0.5 pts, P<0.001; Research: females=13.9±4.8 pts vs. males=17.1±2.9 pts, P=0.009), and trunk stability push-up (Composite: females=2.2±0.7 pts vs. males= 2.6±0.5 pts, P=0.043; Research: females=13.9±4.8 pts vs. males =17.1±2.9 pts, P=0.009). Females also scored significantly lower than males on both the composite [females=13.8±1.8 pts, 95% C.I.(13.2, 14.5), males=15.3±2.1 pts, 95% C.I.(14.5, 16.0), ES=0.82, P=0.004] and research total scores [females=53.2±10.7 pts, 95% C.I.(49.2, 57.3), males=63.1±12.5 pts, 95% C.I.(58.5, 67.7), ES=0.91, P=0.001]. **Conclusions**: Healthy female athletes did not perform as well as healthy male athletes on the FMS, as indicated by lower individual test and total scores. The individual tests (hurdle step, in-line lunge, and trunk stability push-up) that females scored lower than males incorporate components of core stability, balance, postural control, and strength. These results indicate that females may be at a higher risk for injury than males, possibly due to deficits in core stabilization, neuromuscular control, and coordinated movement patterns. Clinicians should be aware of these sex differences when using the FMS and developing injury prevention programs to address potential injury risk factors. Further research is warranted regarding sex differences, and interventions to improve FMS scores.

Kinematic Differences Between Those With And Without Medial Knee Displacement During A Single Leg Squat

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Context: Knee valgus is described as a risk factor for lower extremity (LE) injuries, such as ACL rupture. Clinical movement assessments are an important aspect of injury prevention screening and program development, as laboratory based motion analysis testing for knee valgus motion is not clinically feasible. Identifying medial knee displacement (MKD) as a marker of knee valgus motion is described during clinical movement assessments; however, the validity of MKD as an indicator of valgus motion has yet to be determined. **Objective:** To compare frontal and transverse plane knee and hip angles between participants who display visual MKD (MKD group) during a single leg squat (SLS) to those who do not (CON group). **Design:** Cross-sectional. **Setting:** Research laboratory. **Participants:** Forty, healthy, physically active adults volunteered to participate in this study (CON: n=20, age=20.2±1.5yr, height= 173.1± 10.1cm, mass= 71.0±14.6kg; MKD: n=20, age=20.2±1.8yr, height= 173.8± 8.8cm, mass=71.8±14.7kg). MKD members displayed medial displacement of the patella relative to the great toe on at least three of five SLS trials, whereas the CON members maintained neutral patellar alignment. **Interventions:** Participants completed five SLS trials to 60-degrees of knee flexion with their dominant leg foot flat on the ground, toes pointed forward, and non-dominant leg flexed at the hip and knee. An electromagnetic motion tracking system was used to quantify knee and hip joint angles during the

descent phase (initiation of knee flexion to peak knee flexion). **Main Outcome Measures:** Peak frontal and transverse plane knee and hip joint angles were averaged across five trials. A single MANOVA was performed to compare peak frontal and transverse plane knee and hip joint angles between groups. Follow-up one-way ANOVAs were performed as post-hoc analyses. **Results:** A significant difference was identified between the MKD and CON group kinematics (Wilks' Lambda=.575, $F_{7,32}$=3.130, *P*=.012, ˜ ^{2}=.406). Follow-up one-way ANOVAs revealed significantly greater peak knee valgus ($F_{1,38}$=15.263, *P*<.001) in the MKD (-12.79±5.62) compared to the CON (-6.08±5.23). There were no other significant differences between groups for peak knee flexion (*P*=.320, effect size=.459), knee external (*P*=.905, effect size=.038) or internal rotation (*P*=.486, effect size=.222), hip adduction (*P*=.497, effect size=.217), or hip external (*P*=.877, effect size=.049) or internal rotation (*P*=.416, effect size=.260) (˜ d".05). **Conclusions:** Visual observation of MKD is a biomechanically valid clinical assessment of peak knee valgus angle during a SLS. On average, there was 6-degrees more peak knee valgus in the MKD compared to the CON group, which represents a large difference between groups (effect size=1.24). In contrast, the presence of MKD does not appear to be indicative of increased knee rotation, hip rotation, or hip adduction. While the presence of MKD is a valid indicator of increased knee valgus motion, the relationship between MKD and increased risk of LE injury requires further study.

Medial Knee Displacement Is Associated With Youth Soccer Player Sex And Age

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Context: Sex differences in lower extremity injury biomechanics may influence the greater incidence of ACL injury in female youth soccer athletes. However, it is not clear when sex differences in lower extremity biomechanics, such as medial knee displacement (MKD) emerge during maturation. **Objective:** The purpose of this study was two-fold: 1) Determine if there is a relationship between sex and MKD frequency, 2) Determine if there is a difference in MKD prevalence between females and males across age-groups. Design: **Cross-Sectional.** Setting: **Field laboratory.** Patients or Other Participants: Elite-level club soccer athletes (n= 214) in middle school (11-13 year old age-group) (44 males, 48 females; age= 12 ±1 yrs, height= 153.4 ±7.7 cm, mass= 40.4 ±6.2 Kg) and high school (14-18 year old age-group) (66 males, 56 females; age= 16 ±1 yrs, height= 169.9 ±8.1 cm, mass= 59.7 ±8.6 Kg) volunteered for this study. **Interventions:** Participants performed 3 jump-landings from a 30-cm high box at a distance half of each individual's height from a white line marked on the ground in front of the box. Participants were instructed to jump from the box, land forward of the line, then immediately jump for maximum height. **Main Outcome Measure:** Participants were videotaped and evaluated for the presence of MKD (at least one instance of the center of the patella displaced medial to, or in-line with the great toe) during ground contact. Chi-square tests of association were conducted to determine if MKD frequency was associated with sex between age-groups. Odds ratios (OR) were calculated if a significant (*P* <0.05) association was observed. Results: Overall, there was a significant association between sex and MKD frequency (X^2 (1, N= 214)= 11.90, *P* <0.001); females demonstrated greater MKD frequency compared to males (OR= 3.69, 95% CI= 1.70, 7.99). There was no association between sex and MKD frequency in the middle school age-group (X^2 (1, N= 92)= 1.01, *P*= 0.315). However, an association between sex and MKD was observed in the high school age-group (X^2 (1, N= 122)= 13.42, *P* <0.001); females demonstrated a greater MKD frequency compared to males (OR= 8.24, 95% CI= 2.31, 29.45). **Conclusions:** The sex difference in MKD prevalence appears to be driven by age, as there was no sex difference in the prevalence of MKD between middle school-aged soccer athletes. However, high school-aged female soccer athletes had over 8 times greater odds of MKD compared to their male counterparts. MKD is commonly observed during ACL injury episodes. The higher prevalence of MKD in high school female soccer athletes may help explain the rise in ACL injury risk in females from middle school to high school. Acknowledgements: Funding provided by the National Academy of Sports Medicine and the National Basketball Athletic Trainers Association.

Landing Error Scoring System (LESS) Differences Between Single-Sport And Multi-Sport Female High School Athletes

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Context: The prevalence of single sport specialization (SSS) is becoming more popular in youth sports. Deficits in functional movement have been shown to predispose athletes to injury. With this increase in early SSS, it is unclear whether there is a link between SSS and an increased risk of knee injury. **Objective:** The purpose of this study was to identify functional movement deficits between SSS athletes and multi-sport (M-S) athletes. The study goal was to identify associations that would aid in the development of specialized training programs that could be implemented throughout the year to reduce the risk of injury. **Design:** Observational study. **Setting:** A soccer practice field and sports medicine research laboratory. **Patients or Other Participants:** Forty (n = 21 SSS, n = 19 M-S) female high school athlete volunteers, ages 14-18 (Mean age 15.18 SD+/- 1.12) were recruited through local soccer clubs and an Olympic Development Program (ODP). All single sport athletes played soccer. **Interventions:** All participants completed 3 trials of the standard LESS jump landing task which was recorded and then analyzed at a later date. The subjects performed a double-leg jump from a 30cm platform, landing on a rubber mat at a distance of half their body height. Upon landing, the subjects immediately performed a maximum vertical jump. **Main Outcome Measures:** Values were assigned to each trial using the LESS scoring criteria. The LESS score is a count of "errors" on a range of easily observable items of movement with a total of 17 scored items. Scores range from 0-3 errors (Excellent), 4-5 (Good), 6 (Moderate), and 7 or more (Poor). The 3 scored trials were then averaged before a t-test was utilized to test statistical significance between groups. Alpha was set a priori at 0.05. **Results:** Mean scores for SSS group were 6.84 (SD ± 1.81) while the mean scores for the M-S group were 6.07 (SD ± 1.93). T-value = 1.309 (P>.05) **Conclusions:** These results indicate that participation in soccer alone, compared to participation in multiple sports does not significantly impact LESS scores in adolescent female soccer players. However, the LESS scores indicate that the majority of athletes are at moderate risk for a knee injury regardless of the number of sports played (mean LESS score in the moderate to poor range). Adolescent athletes should participate in training that works to correct these deficits in order to reduce injury risk. More research is needed to identify what interventions would be most successful at reducing these risks.

Predicting Clinical Concussion Measures At Baseline Based On Academic Profile And Motivation

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Context: Baseline concussion measures may be influenced by an athlete's academic abilities. Likewise, previous research suggest that an athlete's level of motivation at the time of testing influences baseline testing performance. **Objective:** To determine if unweighted high school grade point average (hsGPA), Scholastic Assessment Test (SAT) scores, and motivation scores predict neurocognitive and postural control performance at baseline. **Design:** Cross-sectional study. **Setting:** Clinical-Research Center. **Participants:** 88 NCAA Division 1 incoming student-athletes for which all predictor variables were available to the researchers (age: 18.58±0.52 years, height: 175.67±12.75 cm, mass: 15.85±20.28 kg). Participants reported for baseline testing prior to their playing season. **Interventions:** Participants completed a computerized neurocognitive test (CNS Vital Signs), a balance exam (Sensory Organization Test: SOT), and a measure of test-taking motivation (Rey's Dot Counting Test). Motivation was assessed following completion of the baseline concussion assessment. SAT and hsGPA were obtained from the university admissions and registrar offices. **Main Outcome Measures:** The following domains standard scores were taken from the neurocognitive test battery and used as criterion variables: verbal memory, visual memory, psychomotor speed, reaction time, complex attention, cognitive flexibility, processing speed, executive functioning, and reasoning. The composite equilibrium score was used from the SOT as a criterion variable for balance. Ten separate multivariate regression models were used with SAT, hsGPA, and motivation as predictors (*a priori* alpha =0.05). **Results:** hsGPA was a significant predictor of the processing speed standard score (103.73±15.57, $F_{3,82}$=3.73, p = 0.014; R^2=0.12). SAT score was a significant predictor of the complex attention standard score (95.07±36.40, $F_{3,82}$=3.32, p = 0.024; R^2=0.11) and the SOT composite score (76.90±7.07, $F_{3,78}$=6.31, p = <0.001; R^2=0.20). However, these models explained only 12% of the variance in the processing speed standard score, 11% of the variance in the complex attention standard score, and 20% of the variance in the SOT Composite score. We did not observe any other significant predictors. **Conclusions:** Baseline motivation, SAT score, and hsGPA explained some of variance in baseline measures of cognitive flexibility, processing speed, and postural control. However, our model does not explain enough of the variance in these scores to be able to accurately estimate an athlete's baseline performance. Further research is necessary to identify other factors that might help clinicians better assess the validity of an athletes' neurocognitive and postural control measures relative to their individual capabilities. We suggest that clinicians continue to consider motivation and academic profile when interpreting baseline and post-concussion measures in the clinical decision making process as some of the variance was explained with these variables. Academic profile information can also be easily obtained via a demographic questionnaire prior to baseline testing.

The Acute Effect Of Stimulant Ingestion On ImPACT Test Performance

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Context: The management of mild traumatic brain injury (MTBI) has become an area of great concern and controversy in the athletic setting. Numerous states have adopted legislation mandating evaluation procedures and return to play criteria for interscholastic athletics, while other sport governing bodies have adopted similar policies. Many of these recommend neurocognitive tests like Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT™) as a management tool. Due to the restrictive nature of current management plans, anecdotal concerns have been raised regarding athletes trying to cheat the assessment and return to play sooner. Various stimulants have been shown to improve reaction time, visual information processing and working memory, which are similar to the tasks used during ImPACT™. Thus, it is possible that stimulant use could improve performance during neurocognitive testing for MTBI. **Objective:** The purpose of this investigation was to examine the effects of a nutritional supplement containing stimulants on ImPACT™ performance. **Design:** A randomized and counterbalanced double blind cross over design was used. **Setting:** ImPACT™ was performed on a desktop computer in a quiet, fully enclosed and illuminated room at normal room temperature. **Participants:** Health males and females (age=20.6±1.2 y, height= 168.5±10.7 cm, mass= 67.6 ±15.2 kg) with no history of physician diagnosed head injury, learning disability or any form of attention deficit disorder volunteered. Potential subjects were excluded if they were prescribed any type of stimulant or monoamine oxidase inhibitor for regular use. **Interventions:** Subjects were assessed at the same time of day under three conditions, treatment, placebo and control with each separated by a period of one week. During the treatment condition, subjects ingested 5.5 g of a supplement (Jacked 3D™, USPlabs) containing a proprietary blend that included caffeine and 1,3-dimethylamylamine (DMAA) in capsule form with water. The placebo condition consisted of 5.5 g of dextrose in identical capsule form. **Main Outcome Measures:** ImPACT™ composite scores for verbal and visual memory, visual motor speed, reaction time, impulse control and a cognitive efficiency index (CEI) were compared under each of the three conditions and were assessed 30 min after ingestion. **Results:** A significant difference was observed ($F_{2,22}$=4.31, p=.026) when comparing reaction time, as the subjects reacted faster during the treatment condition (.535±.03 s) as compared to the placebo (.553±.03 s) and control (.554±.03 s) conditions. A significant difference ($F_{2,22}$=4.07, p=.031) was also observed for the CEI, as the subjects scored higher during the treatment condition (.486±.09) as compared to the placebo (.415±.10) and control (.409±.12) conditions. **Conclusions:** The results suggest that stimulant ingestion 30 min prior to test administration results in improved reaction time, visual processing speed and memory. However, the question of clinical significance remains, as it is unclear if this would result in an earlier return to play decision.

The Number Of Words And Word Choice Can Improve The Standardized Assessment Of Concussion Scores

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Context: The Standardized Assessment of Concussion (SAC) is a common concussion-screening tool used to assess the effects of sport-related concussions. The baseline-post injury comparison recommended by the National Athletic Trainers' Association (NATA) is an individual-centered approach that emphasizes the validity and accuracy of baseline test scores. The validity of the SAC baseline memory scores has been questioned with because many of the memory items not do meet acceptable psychometric thresholds, mostly because the items are "too easy." **Objective:** To create 5 alternative version of the immediate and delayed memory section and then compare the original version to the 5 alternative memory versions using Rasch modeling. **Design**: Observational design. **Setting:** Laboratory. **Participants:** Six hundred twenty-five participants with no history of concussion in the previous 6 months (aged 21.38 ± 1.77 yrs; n = 282 men, n = 343 women) volunteered for this study. **Intervention:** Participants were given 1 of 6 different versions of the SAC. Each version had a different memory subset (S1 = Original SAC, S2 = All words from the original 3 versions (5items) given in one list, S3 = 10 new words, S4 = 10 new words, S5 = 10 new words, and S6 = S3+8 news words+8 new words). Common items (orientation and concentration items) were used to anchor the 6 versions so the all memory items would be placed on the common metric in relative position. **Main Outcome Measures:** The Rasch-calibrated item difficulties for the

memory items for the 6 SAC versions. A one-way ANOVA with post-hoc analysis was performed to assess if there were any differences across the memory items for the 6 versions (˜ = 0.05). Descriptive statistics of the participants' abilities were examined. **Results:** Mean item difficulty, standard deviation and range for each version: (mean ± SD; Range): S1 (-2.05 ± 1.88; -4.86 to 1.38 logits), S2 (0.61 ± 1.15; -1.96 to 2.01 logits), S3 (0.17 ± 1.32; -4.01 to 1.75 logits), S4 (0.54 ± 1.03; -2.01 to 2.13 logits), S5 (0.59 ± 1.00; -2.36 to 3.26 logits), and S6 (0.85 ± 1.28; -4.86 to 3.26 logits). There was a significant difference in mean difficulty between versions ($F(5,196) = 29.8$; $P = 0.05$). S1 was significantly different than the other 5 versions. Mean person abilities for each version were S1 (0.79 ± 0.89 logits), S2 (0.13 ± 0.53 logits), S3 (0.03 ± 0.54 logits), S4 (0.25 ± 0.76 logits), S5 (0.25 ± 0.53 logits), and S6 (0.33 ± 0.41 logits). **Conclusions:** Our results show that increasing the amount of words and word difficulty can improve the precision of baseline scores. Even though 6 different versions were administered, Rasch modeling allows for person's ability to be placed on the same scale.

Rasch Model Fit Indices May Help Identify Effort With Baseline Concussion Testing

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Context: One major problem facing pre-season concussion testing is the assumption that athletes give 100 percent effort, forcing scores to reflect current "true" ability to make post-injury comparisons possible. It is all too common that professional athletes indicate that they deliberately do poorly on the baseline test to avoid not playing after scoring poorly on the second test following a concussion. This intentional deceit represents a major problem in concussion testing. While some concussion-testing programs attempt to identify abnormal performance, they are severely limited in capability. There is a need to develop methodology to identify abnormal responses associated with sub-maximal effort in concussion testing. **Objective**: To examine various Rasch-based person fit indices and thresholds for operationalize a participant giving full effort. **Design**: Observational design. **Setting**: Laboratory. **Patients or Other Participants**: Six hundred and twenty-five participants with no history of concussion in the previous 6 months (mean ± sd: aged 21.38 ± 1.86 years; n= 282 men, n= 343 women) volunteered for this study. Because participants had no reason to not want to do well on the baseline test, it is assumed that all participants gave full effort. **Interventions**: Participants were administered 1 of 6 versions of the Standardized Assessment of Concussion. Data from all 6 versions were calibrated using the Rasch model using common items (orientation and concentration) as anchor items and model data fit was good. Person ability estimates were calculated with appropriate infit and outfit statistics. These fit statistics represent how well the examinees' responses match the expected responses from the model. The advantage of the Rasch model is that it is highly unlikely an examinee would know which items to respond positively to, thus increasing the number of abnormal responses resulting in an elevated fit index. Thresholds below 1.5 and 2.0 were used to identify participants giving full effort. Data were analyzed with Winsteps 3.75.0. Any person with fit indices greater than the thresholds was considered to be misfit. **Main Outcome Measures**: The dependent variables were the number of people with fit indices greater than the threshold. The smaller the number of full-effort people that fall outside the threshold, the better the performance of the threshold. **Results**: Using the 1.5-fit threshold, 15/625 (2.4%) of participants were identified by the infit statistic, 33/625 (5.3%) by the outfit, and 40/625 (6.4%) by either infit or outfit. Using the 2.0 threshold, 0/625 (0%) participants were identified by the infit statistic, 20/625 (3.2%) by the outfit, and 20/625 (3.2%) by either infit or outfit. **Conclusions**: Effort is essential to ensure validity during concussion testing. Both thresholds performed well in classifying participants as full effort. These results support the examination of these thresholds in a large diagnostic accuracy study.

Influences On Annual Computerized Neurocognitive Baseline Test Performance In Collegiate Student-Athletes

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Context: Baseline neurocognitive testing aids clinicians in the management of sport-related concussions, but no universal guidelines have been determined for frequency of reassessment. Research has shown significant change over time in high school student-athletes' scores warranting annual reassessments, but it is unknown if collegiate student-athletes should be similarly tested. **Objective:** To determine which factors significantly predict Concussion Resolution Index (CRI) baseline measurements. **Design:** Retrospective Case Series **Setting:** Sports Medicine Clinic **Patients or Other Participants:** 450 Division I varsity student-athletes (274 males/ 176 females; age: 19±1years) **Interventions:** A retrospective analysis was completed on CRI baseline tests administered between August 2006 and December 2011. **Main Outcome Measures:** CRI composite scores: complex reaction time (CRT), simple reaction time(SRT), and processing speed(PS) were collected for repeated baseline tests. Prediction variables included age, gender, history of concussion, history of learning disorder, time between baseline tests, performance on initial baseline test, performance on most recent baseline test, and sport. Grouping was performed using number of consecutive tests taken and analysis of predictors for each test (2^{nd}, 3^{rd}, 4^{th}, and 5^{th} baselines) included only those subjects who had taken the corresponding number of tests (i.e. all subjects did not complete 5 consecutive tests). Step-wise linear regression models were fit to determine which factors predicted subsequent baseline test scores. **Results:** Regression analyses revealed various predictors among composite scores. Initial baseline score was a significant predictor of all composites (Test 2: CRT, $r^{2\tilde{}}=0.303, p<0.001$; SRT, $r^{2\tilde{}} = 0.232, p<0.001$; PS, $r^{2\tilde{}} =0.495, p<0.001$; Test 3: CRT, $r^{2\tilde{}} =0.05, p<0.001$; SRT, $r^{2\tilde{}} =0.078, p<0.001$; PS, $r^{2\tilde{}}=0.034, p<0.001$; Test 4: CRT, $r^{2\tilde{}}=0.027, p=0.03$; PS, $r^{2\tilde{}}=0.02, p=0.004$; Test 5: SRT, $r^{2\tilde{}}=0.234, p=0.006$) except Test 4 SRT ($r^{2\tilde{}}=0.348, p=0.226$) and Test 5 CRT ($r^{2\tilde{}}=0.491, p=0.169$) and PS ($r^{2\tilde{}}=0.681, p=0.48$). Most recent baseline score was a significant predictor of all composites on all tests taken (Test 3: CRT, $r^{2\tilde{}}=0.298$; SRT, $r^{2\tilde{}}=0.32$; PS, $r^{2\tilde{}}=0.593$; Test 4: CRT, $r^{2\tilde{}}=0.552$; SRT, $r^{2\tilde{}}=0.289$; PS, $r^{2\tilde{}}=0.801$; Test 5: CRT, $r^{2\tilde{}}=0.491$; SRT, $r^{2\tilde{}}=0.393$; PS, $r^{2\tilde{}}=0.681$; $p<0.005$ for all). Additionally, CRT was predicted by gender, showing females performed better than males (Test 2, $r^{2\tilde{}}=0.18, p=0.001$) and age, showing an improvement in score as age increased (Test 3, $r^{2\tilde{}}= 0.016$, $p=0.044$). SRT was predicted by sport (Test 3, $r^{2\tilde{}}=0.019, p=0.021$) and history of concussion (Test 4, $r^{2\tilde{}}=0.059, p=0.011$). PS was significantly predicted by gender (Test 2, $r^{2\tilde{}}=0.018, p\hat{}0.001$). **Conclusions:** These results show that initial and most recent baseline tests are the most useful in predicting subsequent CRI performance. There was, however, no consistency in a single demographic or self-report variable as a predictor of neurocognitive function. This could indicate influence of some unknown, unmeasured factors such as maturation, sport type (i.e. collision vs. non-collision), duration/level of participation, testing environment and frequency of testing. Until these factors are investigated and can be controlled, it is recommended that reassessment of collegiate student-athletes occur annually.

Baseline Factors Affecting Neurocognitive Performance On A Concussion Assessment Test

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Context: Baseline concussion testing of all athletes has been recommended, so that measures of athletes' pre-injury performance can be used as an accurate comparison post-injury. Widespread baseline testing is not always feasible and recent literature has shown that comparison to normative data agrees with comparison to individualized baselines for the majority of neurocognitive domains. However, certain individuals, such as those with learning disabilities and a history of concussion may benefit from individualized baselines. **Objective:** To determine the effect of previous concussion history, presence of learning disability, psychiatric disorder and baseline total symptom score on neurocognitive performance. **Design:** Cross-sectional. **Setting:** Clinical research center. **Patients or Other Participants:** Two-hundred forty Division I college athletes (age: 19.41±1.21, height: 70.01±4.90 in, weight: 78.12±18.03 kg). Individuals identified with a previous concussion, learning disability, attention deficit hyperactivity disorder (ADHD) or psychiatric disorder and/or a total baseline symptom score of 5 or more were placed into a significant history group (HX, n=121), all other individuals were placed into a control group (CON, n=119). **Interventions:** Subjects were administered the computerized neurocognitive test CNS Vital Signs (CNSVS), including a baseline symptom checklist and a history questionnaire. The main outcome measures of the HX and CON group were compared using independent t-tests. **Main Outcome Measures:** CNSVS standard scores for verbal memory, visual memory, processing speed, executive function, psychomotor speed, reaction time, complex attention and cognitive flexibility. **Results:** The HX group demonstrated significantly lower scores, indicating worse performance on 4 of the 8 CNSVS domains analyzed, including verbal memory (94.59±19.72 vs. 100.98±17.95, p=0.009), executive function (95.12±18.922 vs. 100.54±15.00, p=0.015), complex attention (85.16±68.99 vs. 100.99±26.42, p=0.018) and cognitive flexibility (93.71±20.07 vs. 100.25±15.27, p=0.005). There were no significant differences observed between the groups on visual memory, processing speed, psychomotor speed, or reaction time. **Conclusion:** Certain college athletes, including those with a history of one or more previous concussions, a learning disability, ADHD, psychiatric disorder and/or a total baseline symptom score of 5 or more may perform worse than a normative sample on select neurocognitive domains. Therefore, baseline testing is essential for individuals with a significant history. Additionally, if individuals with a significant history sustain a concussion and do not have a baseline test, their post-injury scores should be interpreted carefully.

The Effect Of The Environment On Sport Concussion Assessment Tool 2 (SCAT2) Scores

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Context: With the incidence of concussion in sport on the rise, it is crucial that the concussion assessment tools utilized by health care professionals be accurately administered. It may be important to consider the environment of test administration between baseline and post-concussion assessment to allow appropriate examination and return to play decisions. Previous work has found that the testing environment alters Balance Error Scoring System scores. However, there is limited research on the effect of testing environment on Sport Concussion Assessment Tool 2 (SCAT2) scores although it is the recommended examination tool for concussion. **Objective:** To determine if testing environment has an effect on SCAT2 scores in healthy collegiate club athletes. **Design:** Experimental, randomized controlled clinical trial. **Setting:** Uncontrolled sideline of an athletic field during a practice and a quiet controlled classroom. **Patients or Other Participants:** A total of 18 healthy male club lacrosse players (age=20.39±1.46 years, height =180.17±6.92 cm, mass=81.89±8.92 kg) and 15 healthy female club soccer players (age=19.41±1.24 years, height=158.53±6.81 cm, mass= 58.85±7.53 kg) with no history of head injury within the last 12 months, no lower extremity injuries reported within the past 2 months, and no history of Attention Deficit Disorder or Attention Deficit Hyperactivity Disorder volunteered to participate. **Interventions:** Participants completed the SCAT2 test in 2

environments, controlled quiet classroom and uncontrolled sideline, in 2 testing sessions approximately 8.05±1.63 days apart. We counter-balanced the testing sessions to reduce a practice effect altering the results. **Main Outcome Measures:** The SCAT2 is a written standardized concussion test comprised of eight components: symptom score, physical signs score, Glasgow coma scale, Maddocks score, cognitive assessment, balance examination, coordination examination, and cognitive assessment. We used a MANOVA to examine the differences between testing environments for the 8 component scores and the total score of the SCAT2. **Results:** We found statistically significant group mean differences between testing environments in the combined dependent variables for males (multivariate $F_{7,28}$=6.759, P<0.001, 1-˜=0.998, ˜^{2}=0.628), females (multivariate $F_{6,23}$=8.306, P<0.001, 1-˜=0.999, ˜^{2}=0.684), and a combination of both sexes (multivariate $F_{7,58}$=11.098, P<0.001, 1-˜=1.000, ˜^{2}=0.573). The modified BESS was most affected by the environmental differences in males ($F_{1,34}$=17.118, P<0.001, 1-˜=0.981, ˜ ^{2}=0.311), females ($F_{1,28}$=23.805, P<0.001, 1-˜=0.997, ˜^{2}=0.432), and both sexes combined ($F_{1,64}$=36.767, P<0.001, 1-˜=1.00, ˜^{2}=0.351). **Conclusions:** SCAT2 scores were impaired when we tested participants in a sideline environment compared with a quiet clinical environment. An outside, uncontrolled environment can potentially alter SCAT2 scores significantly from an inside, controlled environment potentially due to several factors including noise level, weather, playing surface, or interference from coaches and teammates. We recommend baseline SCAT2 testing be administered in an environment in which testing after injury will most likely be conducted.

Psychometric Evaluation Of The Standardized Assessment Of Concussion In High School Student-Athletes

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Context: The Standardized Assessment of Concussion (SAC) is a concussion screening tool used to identify concussions by comparing a baseline score with a post-injury score. Previous studies have examined the validity and reliability of the SAC test; however, one of the most fundamental evaluations, classic item analysis which evaluates the psychometric properties (i.e., item difficulty and discrimination) of the items, has not been examined in high school student-athletes **Objective**: The purpose of this study was to perform an classic item analysis on the SAC in order to examine its validity as a baseline measurement for use in high school student-athletes. **Design**: Observational design. **Setting**: Athletic Trainer administered the SAC in a quiet room away from distractions. **Patients or Other Participants**: One Hundred forty-two high school student-athletes (89=M, 53=F; mean age = 16.13 SD = 1.18) with no history of concussion within the previous 6 months were recruited for this study. **Interventions**: The SAC test is comprised of 4 sections assessing orientation, immediate memory, concentration, and delayed memory. Three versions of the SAC, reported as equivalent, were counterbalanced and given to each participant. **Main Outcome Measures**: Iteman software (V 3.6) was used to calculate item difficulty and item discrimination. Item difficulty (P) is reported as a proportion of those who answered an item correctly. Item discrimination (r_{pb}) is reported as a point biserial correlation. National Commission for Certifying Agencies (NCCA) standards were used to evaluate which item statistics were appropriate. Acceptable item difficulty ranged from 0.10 to 0.92. Acceptable item discrimination was a point-biserial correlation of >0.10. Based on the acceptable item difficulty and acceptable item discrimination, an item determination was determined to decide whether or not the item was acceptable. **Results**: All three versions of the SAC had unacceptable items (A = 50%, B = 60%, C = 63.33%). The vast majority of the unacceptable items were in the orientation and immediate memory sections. All five orientation items were considered unacceptable in the three versions. Of the 15 items in the immediate memory section of versions A, B, and C, there were 10, 12, and 14 unacceptable items, respectively. **Conclusions**: This study demonstrates that some items on the SAC are too easy in the high school population, which produces a ceiling effect. Increasing number of acceptable items in the current SAC is important to ensure the safety of athletes returning to play following concussion. Future research should focus on altering the SAC (i.e., modifying existing items or testing new items) in order to improve the item psychometrics of the SAC.

Quadriceps Activation And Spinal-Reflexive Excitability Predicts Quadriceps Strength Following Anterior Cruciate Ligament Reconstruction

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Context: Quadriceps weakness is common following anterior cruciate ligament reconstruction (ACLr) and often persists long after patients resume normal activity. Neural inhibition of the quadriceps may contribute to this ongoing weakness, which could lead to prolonged disability within this population. New rehabilitative strategies that attempt to overcome neural inhibition by increasing voluntary activation through stimulation of neural pathways have been proposed to improve muscle strength. Understanding how neural excitability and voluntary activation contribute to muscle strength is critical in developing new therapeutic techniques that will ultimately improve function following injury. **Objective:** To evaluate the ability of quadriceps activation and spinal-reflexive excitability to predict quadriceps strength in patients with ACLr. **Design:** Descriptive laboratory study. **Setting:** Research laboratory. **Patients or Other Participants:** Twenty-five patients with a history of ACLr (17 Female, 8 Male; age: 21.5 ± 3.9years; height: 171±10.5cm; weight: 71.8±17.1kg; 49.9±37.8 months post-surgery) who had been medically cleared for full participation in physical activity were included in this study. **Interventions:** Vastus medialis strength, voluntary activation and spinal-reflexive excitability were tested in the injured limb in a random order. **Main Outcome Measures:** Quadriceps strength was assessed via maximal voluntary isometric contractions (MVIC) normalized to body mass (Nm/kg) and performed at 90° of knee flexion in an isokinetic dynamometer. Quadriceps activation was determined by using the central activation ratio (CAR) obtained through the burst superimposition technique. Quadriceps spinal-reflexive excitability was assessed using maximal Hoffmann reflexes normalized to maximal muscle responses (H:M). Simple Pearson Product correlations were performed to determine if spinal-reflex excitability and voluntary activation had a higher relation to strength. Both voluntary activation and spinal-reflexive excitability were hierarchically added into a multiple Linear Regression to determine their ability to predict quadriceps strength. The change in R^2 to the model from the addition of each predictor variable was also analyzed. Alpha was set *a priori* at $P \leq 0.05$. **Results:** H:M ($r = 0.528$; $P<0.01$) had slightly higher relation to MVIC than CAR ($r = 0.525$; $P<0.01$). The overall multiple regression model significantly predicted 45% of the variance in quadriceps strength ($R^2 = 0.451$, $P=0.01$; $MVIC = 1.85_{H:M} + 2.55_{CAR} - 0.081$). Initial imputation of H:M into the model accounted for 27.8% ($R^2=0.278$, $P<0.01$) of the variance in MVIC. The subsequent addition of CAR accounted for a significant increase of 17.3% ($\tilde{}R^2 = 0.173$, $P=0.01$) in the prediction capability of the model. **Conclusions:** Quadriceps activation and spinal-reflexive excitability predicted nearly half of the variance in quadriceps strength of ACLr patients. This may be interpreted as evidence that neural pathways are essential in generating quadriceps strength in ACLr patients. Interventions targeting neural pathways may be beneficial to restore optimal quadriceps strength following surgery and potentially improve function.

Preoperative Quadriceps Activation Is Associated With Postoperative Quadriceps Activation, Not Strength, Following Anterior Cruciate Ligament Reconstruction

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Context: It is well accepted that greater preoperative quadriceps strength leads to a better recovery of strength following anterior cruciate ligament (ACL) reconstruction. Although quadriceps activation failure is considered to contribute to the quadriceps weakness that lingers following ACL reconstruction, the impact of preoperative quadriceps activation on postoperative quadriceps strength and activation is less understood. It seems plausible that better preoperative quadriceps activation can help improve the recovery of quadriceps function post-surgery. Understanding the factors that contribute to the best postoperative quadriceps function could help clinicians design more effective preoperative interventions. **Objective:** Determine if quadriceps activation and strength prior to ACL reconstruction are related to postoperative quadriceps function. **Design:** Descriptive laboratory study. **Setting:** University Laboratory. **Patients or Other Participants:** Thirty-nine individuals post-ACL injury (18 male, 21 female; age 19.21±5.0 yrs; height 1.74±0.01 m; mass 72.89±16.1 kg) reported for testing on two occasions: post-ACL injury (2.47±2.4 months) and post-ACL surgery once they returned to activity (7.35±1.1 months). **Interventions:** Quadriceps activation was assessed using the burst superimposition technique, and quantified by averaging three trials of the central activation ratio. Three maximal knee extension trials collected via an isokinetic dynamometer at 60°/second were averaged and normalized to subject body mass (Nm/kg) to quantify quadriceps strength. **Main Outcome Measures:** Linear regressions were used to examine the relationship between 1) preoperative and postoperative activation, 2) preoperative activation and postoperative strength and 3) preoperative and postoperative strength. **Results:** Preoperative quadriceps activation was found to be associated with postoperative activation (R^2=0.169, b=0.412, P=0.009), but not strength (R^2=0.018, b=-0.134, P=0.416). Preoperative strength was associated with postoperative strength (R^2=0.268, b=0.518, P=0.001). **Conclusions:** ACL patients with better preoperative quadriceps activation and strength recovered quadriceps activation and strength better than those with lower preoperative quadriceps function. Because previous research has demonstrated a relationship between quadriceps activation and strength in healthy individuals, we had anticipated that preoperative quadriceps activation would affect postoperative quadriceps strength. However, our data indicates that preoperative quadriceps activation is not a good predictor of postoperative strength. Preoperative activation may be mediated by other factors such as pain and effusion. Rehabilitation programs for ACL patients should focus on maximizing quadriceps activation and strength prior to surgery to optimize these measurements of quadriceps function postoperatively. Supported by NIH Grant K08 AR053152-01A2

Anterior Cruciate Ligament Injury Causes Biomechanical Alterations In Both The Injured And Non-Injured Leg: The JUMP ACL Study

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Context: Those with anterior cruciate ligament (ACL) injury and reconstruction (ACLR) display lower extremity biomechanics that may predispose them to subsequent ACL injury and osteoarthritis. There is limited evidence regarding whether these factors are induced by ACLR or existed prior to injury. **Objective:** To determine the effect of ACL injury and ACLR on lower extremity biomechanics. **Design:** Repeated measures, case-cohort **Setting:** Research laboratory **Participants:** Seventy participants of the JUMP ACL study, a multi-year prospective study conducted at the United States service academies to identify risk factors for noncontact ACL injury, completed testing for this analysis, 31 who suffered an ACL injury (Cases) and 39 who did not. Because unilateral biomechanics were collected during initial testing, Cases were divided into those that injured the tested limb (ACLR-INJ: n=12 (8 males, 4 females), Age=21.42±0.79 years, Height=174.29±7.56 cm, Mass= 76.25±9.95 kg) and those that injured the non-tested limb (ACLR-NINJ: n=19 (9 males, 10 females), Age= 21.47±0.77 years, Height= 170.05 ±9.13 cm, Mass=72.87±12.78 kg). Participants who never suffered an ACL injury (CON: n=39 (20 males, 19 females), Age=20.98±0.73 years, Height:172.73±8.99 cm, Mass=

73.11±13.16 kg) were matched for cohort year, academy, and gender. **Interventions:** Three-dimensional lower extremity kinematics and kinetics were collected during a double-leg jump landing during initial enrollment in the JUMP ACL study prior to ACL injury and ACLR (Baseline) and following ACL injury and ACLR (Follow-Up). **Main Outcome Measures:** Joint angles at initial ground contact (IGC), peak values during the landing phase (LP), and normalized internal joint moments, vertical ground reaction force (VGRF), and anterior tibial shear force (ATSF) were recorded during LP. Mixed model (Time: Baseline, Follow-Up; Group: ACLR-INJ, ACLR-NINJ, CON) analyses of covariance (Gender) were performed for each dependent variable. **Results:** ACL injury and ACLR caused an increase in hip adduction ($F_{(2,66)}$=3.773, p=0.028) and knee valgus angles ($F_{(2,66)}$=3.957, p=0.024) at IGC for both ACLR-INJ (Hip Adduction: Baseline=-11.12°±6.64°, Follow-Up= 0.02° ±9.65°; Knee Valgus: Baseline =2.61°±6.54°, Follow-Up=-4.22°± 5.78°) and ACLR-NINJ (Hip Adduction: Baseline=-9.00°±6.61°, Follow-Up=0.41°±9.61°; Knee Valgus: Baseline=1.33°±6.51°, Follow-Up=-4.84°±5.76°) groups. Both groups demonstrated a decrease in peak knee varus angle during LP ($F_{(2, 66)}$=5.198, p=0.008) (ACLR-INJ: Baseline=7.48°±7.48°, Follow-Up=1.28°±7.14° ; ACLR-NINJ: Baseline=9.27°±7.44°, Follow-Up=0.55°±7.11°). The ACLR-NINJ group demonstrated an increase in peak knee valgus angle during LP ($F_{(2,66)}$=3.768, p=0.028) (ACLR-INJ: Baseline=-5.26° ±8.19°, Follow-Up=-11.61°±7.74°). The ACLR-INJ group demonstrated a decrease in peak knee extension moment ($F_{(2,66)}$=4.509, p=0.015) (ACLR-INJ: Baseline=-0.23±0.06 Nm/BH*BW, Follow-Up=-0.17± 0.04 Nm/BH*BW), peak hip flexion moment ($F_{(2,66)}$=3.847, p=0.026) (ACLR-INJ: Baseline=-0.26± 0.10 Nm/BH*BW, Follow-Up= -0.14±0.07 Nm/BH* BW), and ATSF ($F_{(2,66)}$=4.530, p=0.014) (ACLR-INJ: Baseline =1.25±0.32 N/BW, Follow-Up=0.92±0.25 N/BW). The CON group only demonstrated an increase in peak internal knee rotation angle during LP ($F_{(2,66)}$=4.204, p=0.019) (CON: Baseline=9.18°±8.66°, Follow-Up=17.10°±8.23°). **Conclusions:** ACL injury and ACLR causes alterations in hip and knee kinematics for both the injured and non-injured limb, and may be related to continued avoidance of loading the injured limb.

Gender Differences In Lower Extremity Neuromuscular Function Following 30 Minutes Of Sub-Maximal Exercise In ACL Reconstructed Individuals

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Context: Return to physical activity is the primary goal of many patients following ACL reconstruction. The effects of a return to exercise in the presence of lower extremity neuromuscular dysfunction remain unclear however; those who return to a higher level a physical activity appear to be at a higher risk for knee joint osteoarthritis (OA). Female patients have been shown to be less likely to return to high levels of physical activity as well as more likely to develop post-traumatic knee joint OA over time. **Objective:** To compare quadriceps neuromuscular function after exercise between males and females with ACL reconstructed knees. **Design:** Descriptive laboratory study. **Setting:** Laboratory. **Patients or Other Participants:** Twenty-six recreationally active persons (13M/ 13F: age=24.1±4.4yrs, height =179.1±9.8cm, mass=80.1±9.4kg, time since surgery= 43.5±37.0mo; age=24.2±5.6yrs, height =163.0 ±5.9cm, mass =62.3 ±8.3kg, time since surgery= 45.8±42.7mo) with a history of unilateral, primary ACL reconstruction at least 6 months prior to testing. **Interventions:** 30 minutes of continuous exercise comprised of repeated bouts of 5 minutes of uphill walking and 1 minute of body weight squatting and step-ups. **Main Outcome Measures:** Normalized knee extension maximal voluntary isometric contraction (MVIC) torque, quadriceps central activation ratio (CAR) before and after exercise. While participants performed maximal isometric knee extension, an electrical stimulus was triggered causing a transient increase in torque (SIB). CAR

was calculated as (MVIC/SIB)*100. Separate 2 (gender: male, female) x 2 (time: baseline, pre-exercise) repeated measures ANOVAs were performed for knee extension torque, superimposed burst torque, and quadriceps CAR. Separate independent samples t-tests were performed to compare pre- to post-exercise change in knee extension torque, superimposed burst torque, and quadriceps CAR between genders. **Results:** There was a significant group x time interaction for knee extension torque ($F_{(1,24)}$= 4.72, *P*=0.04) with females (pre-exercise=2.56±0.70 Nm/kg; post-exercise=2.28±0.65 Nm/kg) experiencing a decline in knee extension torque while males (pre-exercise=2.63±0.68 Nm/kg; post-exercise=2.62±0.55 Nm/kg) did not. There was no significant group x time interaction for quadriceps CAR ($F_{(1,24)}$=4.02, *P*=0.06) however, there was a significant time main effect (*P*=0.02, pre-exercise=75.2±13.4%; post-exercise=71.2±13.2%) for quadriceps CAR with participants experiencing a reduction in quadriceps activation following exercise regardless of group. The percent reduction in knee extension MVIC torque ($t_{(24)}$=2.60, *P*=0.02) and quadriceps CAR ($t_{(24)}$=2.27, *P*=0.03) experienced by male participants (CAR=-1.45±9.45%, MVIC=1.94±12.17%) was smaller than those measured in female participants (CAR=-8.69±6.59%, MVIC=-10.32±11.84%). **Conclusions:** Female participants experienced reductions in isometric knee extension torque and quadriceps central activation ratio following 30 minutes of exercise. The reduced fatigability seen in male participants may be indicative of compensatory strategies developed following ACL reconstruction in order to cope with continuous exercise by decreasing the demand on the quadriceps during exercise.

Unipedal Postural Control After Exercise In Individuals With ACL Reconstructed Knees

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Context: Returning to exercise and sport is a common goal for patients following anterior cruciate ligament reconstruction (ACL-R). Sensorimotor deficits may impede on patients ability to return to pre-injury levels of activity. The effects of exercise in patients with ACL-R may provide information about sensorimotor changes experienced in this population as they return to physical activity. **Objective:** To compare the effects of 36-minutes of continuous exercise on unipedal postural control in ACL-R individuals and healthy controls. **Design:** 2 (Group: ACL-R, control) x 2 (Time: baseline, post-exercise) descriptive laboratory study. **Setting**: Laboratory. **Patients or Other Participants**: Forty recreationally active volunteers: Twenty (sex= 10F/10M, age= 25.5±5.5yrs, height= 1.8±0.1m, mass= 76.7±14.4kg, time-from-surgery: 5.0±4.3yrs) with a history of primary, non-complicated ACL-R at least 6 months prior and twenty healthy controls (sex= 10F/10M, age= 24.6±5.0yrs, height= 1.7±0.1m, mass= 65.2±12.1kg). **Interventions:** A series of 6 repeated cycles (each lasting 6-minutes, total=36 minutes), Each cycle included 5-minutes of inclined treadmill walking and 1-minute of jumping exercises. Heart rate, rating of perceived exertion were monitored prevent exhaustion. **Main Outcome Measures:** Three 10-second trials of static, unipedal stance with eyes closed and arms crossed were assessed using a force plate and center of pressure (COP) excursions. Medial-lateral (COP_{ML-SD}) and anterior posterior (COP_{AP-SD}) standard deviations, velocity (COP_{Vel}), and area (COP_{Area}) were calculated. COP_{ML-SD}, COP_{AP-SD}, and COP_{Area} were analyzed using nonparametric statistics. Group differences at baseline and post-exercise were assessed using Mann-Whitney U tests, and baseline to post-exercise changes in groups were assessed using Wilcoxin Signed Ranks. COP_{Vel} was analyzed using parametric statistics; effects of group and exercise were assessed using a 2x2 ANOVA with repeated measures. **Results:** COP_{ML-SD}, COP_{AP-SD}, or COP_{Area} was no different between groups at baseline or post-exercise. Exercise had no effect on COP_{ML-SD} in the ACL-R group (1.10[0.93, 1.20] to 1.15[0.93,1.38], p=0.530), but significantly increased COP_{ML-SD} in the control group (1.15[0.93, 1.28] to 1.20[1.10, 1.30], p=0.040). Exercise significantly increased COP_{AP-SD} in the ACL-R (1.15[1.00, 1.38] to 1.40[1.10, 1.68], p=0.007) and control (1.20 [1.00, 1.58] to 1.45[1.20, 1.90], p<0.001) groups. Exercise significantly increased COP_{Area} in the ACL-R (22.65[19.20, 26.35] to 29.90[18.65, 39.60], p=0.014) and control (24.55[16.73, 32.98] to 32.85[25.08, 47.35, p=0.023) groups. On average, COP_{Vel} significantly increased (p=0.013) from baseline (ACL-R=8.81±2.24, control=9.92±2.73) to post-exercise (ACL-R=9.69±2.44, control=10.87±2.97), but there were no significant group (p=0.081) or group x time (p=0.415) effects. **Conclusions:** ACL-R does not effect postural control in a rested state. An exercise-induced increase in COP measures suggests individuals must adjust to the constraints of exercise by broadening sensorimotor strategies. ACL-R patients may be limited in their ability to properly adapt to the constraints of exercise. This may place them at greater risk for functional joint problems when attempting to return to sport and exercise.

Quadriceps Function After Repeated Bouts Of Exercise In Patients With ACL Reconstruction

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Context: Quadriceps activation failure and weakness have been reported in patients with anterior cruciate ligament reconstructions (ACL-R). Limited information is available regarding the quadriceps response after exercise in people with ACL-R. **Objective:** To compare neuromuscular function of the quadriceps following repeated bouts of exercise between individuals with and without a history of ACL-R. **Design**: Case-control. **Setting**: Laboratory. **Patients or Other Participants**: Eight subjects with unilateral ACL-R (age=24.8±5.1yrs, height =176.7± 14.2cm, mass=82.9±17.9kg) and 10 healthy subjects (age=26.9±5.3yrs, height=173.8±8.5cm, mass=70.2±12.4kg) participated. **Interventions**: All subjects performed 30 minutes of exercise on two consecutive days. In each 30-min exercise, there were 5 repeated cycles of aerobic and nonaerobic exercise, each of which consisted of 5-mintue incremental treadmill walking and 1-minute of jumping exercises. **Main Outcome Measures**: Knee extension torque and CAR were measured during a knee extension maximal voluntary isometric contraction (MVIC). CAR was measured as the ratio between MVIC and the peak torque generated by an electrical stimulation delivered to the thigh superimposed during the MVIC test. Outcomes were recorded 4 times: before and after exercise on the first and second day of exercise and compared with a 2X4 repeated measures ANOVA and post hoc testing where appropriate. **Results**: There was a significant group by time interaction found for knee extension torque in the reconstructed side limbs ($F_{3,48}$=4.64,P=.006). On day 1, ACL-R (2.85±.33 Nm/kg) were significantly weaker compared to healthy at baseline(3.84±.30 Nm/kg, P=0.01). Knee extension torque significantly decreased approximately 21% following exercise(P=0.01) in the healthy group whereas the ACL-R group only experienced on average a 9% reduction(P=0.13). On day 2, the knee extension torques of the healthy group before exercise were significantly lower than pre-exercise torques on day 1(P=0.03), indicating lack of full recovery of quadriceps strength 24 hours after exercise. In contrast, the pre-exercise knee extension torques of the ACL-R group were not different between day 1 and 2(P=0.73). For a group comparison of pre-exercise torques on Day 2, the ACL-R group tended to have lower knee extension torque compared to healthy controls, but the difference was not statistically significant (P=0.07). Following exercise the extension torques significantly decreased in both groups: approximately 15% reduction found in the healthy group(P<0.001) and approximately 11% reduction found in the ACL-R group(P=0.03) **Conclusions**: ACL-R patients are weaker and less activated than healthy controls. ACL-R patients respond to exercise differently and appear to experience less deterioration of quadriceps strength after a single bout of exercise, but not after 2 bouts of daily exercise.

Fatigue Alters Hip Biomechanics And Postural Stability In Females With Anterior Cruciate Ligament Reconstruction

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Context: Females with a history of ACL injury and subsequent surgical reconstruction (ACLR) are at high risk for future ACL injury. Fatigue may influence the increased risk of future injury in these individuals by altering lower extremity (LE) biomechanics or balance. However, there is limited research investigating the effects of fatigue in females with ACLR. **Objective:** To determine the effect of fatigue on hip and knee biomechanics and balance in females with ACLR. Design: **Cross-sectional, repeated measures.** Setting: **Research laboratory.** Patients or Other Participants: **Fourteen** physically active females with ACLR (age=19.64±1.5 years; height= 163.52±6.18 cm; weight=62.6±13.97 kg) volunteered for this study. **Interventions:** Participants performed a fatigue protocol consisting of repeated, weighted squats (30% bodyweight) from 0° to 60° of knee flexion at a rate of 25 squat cycles per minute. The fatigue protocol was terminated when participants fell four squat cycles behind the set rate or failed to complete two sequential squat cycles. LE biomechanics were assessed during five jump-landing trials. The jump-landing task consisted of participants jumping forward (distance=50% of body height) from a box (height=30 cm) onto a force plate. Balance was assessed as participants stood on their involved limb with their eyes closed (3 trials, 20 sec each trial) while on a force plate. All measures were performed

before and after the fatigue protocol on the ACLR limb. Paired *t*-tests were performed to compare LE biomechanics and balance variables before and after the fatigue protocol. **Main Outcome Measures:** LE biomechanical variables were defined as three-dimensional hip and knee joint displacements (degrees) and peak joint moments (normalized to body weight * height). These variables were averaged across 5-trials during the loading phase (time from initial contact to peak knee flexion). Balance was quantified as the sway path (cm), averaged across 3-trials. Results: Hip flexion displacement (t=2.23, P=0.044; pre-fatigue=45.19±14.10, post-fatigue=47.48±14.21) and moment (t=2.14; P=0.052; pre-fatigue=1.66±0.68, post-fatigue= 1.91±0.62) were significantly increased from pre- to post-fatigue. No other LE biomechanical variables were altered after fatigue (P>0.05). Sway path was also significantly increased after the fatigue protocol (t=3.925; P=0.002; pre-fatigue =102.54±19.36 cm, post-fatigue =124±34.51 cm). **Conclusions:** We observed increased hip flexion displacement and moment during a jump-landing and decreased single-leg balance in females ACLR limb after fatigue. Increased hip flexion is described during ACL injury mechanisms and decreased balance is associated with increased risk of future ACL injury in those with ACLR. Thus, fatigue in ACLR females may partially explain the high risk of future ACL injury in these individuals. Future research examining the relationship between fatigue and risk of future ACL injury in those with ACLR is warranted.

Differences In Self-Reported Pain And Function For Patients With Anterior Cruciate Ligament Injury When Compared According To Bone Bruise Lesion Severity

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Context: There is inconsistent evidence regarding differences in self-reported pain and function in patients following anterior cruciate ligament (ACL) injury when compared according to the presence or absence of bone bruise lesions (BBL). Classifying individuals based on the severity of the BBL is more specific and may provide better criteria for stratifying self-reported pain and function in ACL-injured patients. **Objective:** To determine if differences in self-reported pain and function would be observed for patients with differing BBL severities (Costa-Paz (CPC) I, II, or III). **Design:** Cross-sectional. **Setting:** Orthopaedic clinic. **Patients or Other Participants:** A convenience sample of 51 subjects participated. Only one subject was classified as CPC-I; therefore, the final analysis includes only patients with CPC-II and CPC-III BBL (CPC-II: 15males, 13females, age:21.8±9.2years, height: 172.7± 8.2cm, mass:74.5 ±19.7kg, CPC-III: 11males, 11 females, age:20.3 ±8.8years, height: 174.8±9.3cm, mass: 78.1± 19.5kg). Subjects had an MRI documenting ACL injury and concomitant BBL, and an evaluation by orthopaedic physician within 4 weeks following injury. **Interventions:** The severity of each BBL was determined and subjects were classified according to their most severe BBL (CPC-II: n=28; CPC-III: n=22). **Main Outcome Measures:** Three patient reported outcome measures were completed (Knee Injury and Osteoarthritis Outcome Score (KOOS)), International Knee Documentation Committee (IKDC), and the Short-Form 12 (SF-12). The dependent variables (DV) were scores on the KOOS subscales: KOOS-Pain, KOOS-Function, KOOS-Activities of Daily Living, KOOS-Quality of Life (QOL), KOOS-Sport, the IKDC score and the SF-12 Physical and Mental components. An ANCOVA was employed to determine if differences in the DV are present when subjects are compared according to differing BBL severities (CPC-II and CPC-III). Covariates included age, total number of BBL, total BBL volume and time elapsed from injury to data collection. Alpha was set a priori at $p<0.05$. Adjusted means and associated 95% confidence intervals (95%CI) are presented for significant differences. **Results:** While controlling for confounding variables, the results indicated patients with CPC-III BBL reported lower scores on the KOOS-Sport (9.6, 95%CI:2.0-17.2) compared to patients with CPC-II BBL (21.5, 95%CI:14.7-28.3, p=0.03). In addition, while controlling for confounding variables, the results indicated patients with CPC-III BBL reported lower scores on the KOOS-QOL (23.9, 95%CI:17.1-30.8) compared to patients with CPC-II BBL (34.6, 95%CI:28.5-40.7, p=0.03). There were no other significant differences between the two groups for all other DVs (p>0.05). **Conclusions:** The severity of BBL influences several patient reported outcomes including the KOOS-Sport and KOOS-QOL. When confounding variables are controlled for, subjects with CPC-III BBL reported greater difficulty in performing sport related activities and lower quality of life scores compared to the CPC-II group. Our findings support the impact of concomitant BBL on patient reported outcomes in patients with ACL injury and the use of a severity classification system for future research studies investigating BBL outcomes.

Bilateral Knee Osteochondritis Dissecans In An Adolescent Male Athlete

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Background: This case presents a 17-year-old male student-athlete who participates in football, basketball and weight lifting. Patient presented with chief complaint of sharp pain and weakness of the left knee. Initial injury occurred seven months earlier when the patient twisted his left knee landing a jump. Initially left knee was stiff but not painful. He finished football and basketball season but discomfort progressively increased. Resting alleviated symptoms while activity exacerbated his pain, weakness and discomfort. Patient had no prior history of left knee pathology. Examination revealed mild left knee effusion. Patient had point tenderness over the distal medial femoral condyle (MFC) and medial joint line. Left knee ROM was 0ˆ-120ˆ; right knee was 0ˆ-140ˆ. A slight increase in pain noted with McMurray's testing, negative Wilson's test was present. Radiographs and magnetic resonance imaging (MRI) of the left knee were obtained prior to surgical intervention. At the patient's one year follow-up his chief complaint was persistent knee pain of the contralateral knee with insidious onset. Symptoms included right knee popping, catching and clicking with running and walking, and change in his gait pattern. Patient was tender to palpation over right medial joint line and MFC. Right knee ROM was 0ˆ-120ˆ with pain at terminal flexion. ROM of left knee was 0ˆ-130 without pain. Patient had right knee pain with valgus stress. Radiographs and MRI of right knee were then obtained. **Differential Diagnosis:** Spontaneous osetonecrosis of the knee, medial collateral ligament injury, insufficiency fracture, chondroblastoma, osteosarcoma, chondral fracture/stress fracture, osteochondritis dissecans (OCD), synovial chondromatosis, infection/ osteomyelitis, meniscal pathology, rheumatoid arthritis, slipped capital femoral epiphysis (SCFE). **Treatment:** Radiographs and MRI of left knee showed evidence of 15 mm OCD lesion involving the weightbearing MFC with intact overlying cartilage. Based on imaging, physical examination, and failure of conservative management, a left knee arthroscopy and retrograde drilling of MFC with chondroplasty was performed. Postoperatively treatment included pain medications, knee brace, crutches, and physical therapy. Patient was extremely satisfied with left knee procedure outcome at one year follow-up and had returned to sport without recurrent symptoms. Radiographs and MRI of right knee revealed similar OCD lesion involving the inferior lateral aspect of the MFC and evidence of open growth plates. Conservative treatment trial was recommended prior to any additional surgical procedures. **Uniqueness:** Symptomatic OCD lesions are rare and can be commonly overlooked on radiographic studies. Bilateral lesions are even more uncommon (only 15-30% of cases). Etiology of OCD lesions remains unclear, but has been linked to repetitive trauma. OCD lesions classically involve lateral aspect of MFC (51% of cases). OCD lesions in skeletally immature patients are most likely to heal with or without surgical intervention. In this case, surgical intervention stimulated healing of OCD lesion after skeletal maturity. OCD lesions that fail to heal are commonly treated with cartilage restoration procedures (including autograft or allograft mosaicplasty/ OATS). OCD lesions originate prior to skeletal maturity and should not be confused with osteochondral defects, which are traumatic in origin and commonly occur after skeletal maturity. **Conclusions:** The patient is an adolescent athlete diagnosed with symptomatic OCD lesions of bilateral MFC's. Surgery was recommended in hope of decreasing likelihood of progression to an unstable OCD and potential loose body. OCD that become unstable can lead to degenerative joint problems including osteoarthritis. OCD is a rare disease in the general population, an important cause of joint pain in physically active adolescents, and proper diagnosis and treatment of a young athlete by sports medicine professional is pertinent to joint preservation.

Osteochondral Allograft Transplantation In A NCAA Division Ii Intercollegiate Women's Basketball Athlete

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Background: A 20-year-old female intercollegiate basketball player experienced pain and effusion of an insidious onset during preseason workouts in September of 2010. The patient's chief complaints were pain and stiffness along the medial patellofemoral border and joint line. The patient also stated she felt a palpable soft tissue mass along the medial patellofemoral border following workouts. During examination, the athletic trainer found no signs of trauma other than superior and medial joint effusion indicative of intra articular injury to the knee. Ligamentous and functional testing provided little evidence as to the causation of the effusion. The patient was referred to the Team Physician for further evaluation following two weeks of minimal progression with symptomatic interventions of NSAIDs, intermittent compression, and quad strengthening. **Differential Diagnosis:** Patellar Tendinitis, Medial Retinacular Sprain, Chondramalacia, Symptomatic Synovial Plica, Patellofemoral Pain Syndrome, Patellofemoral Instability. **Treatment:** Following examination by the Team Physician, an MRI was ordered to rule out structural deformities and identify the palpable soft tissue mass. Results of the MRI concluded a full thickness chondral injury to the patella along with a separated fragment from the inferior pole. The individual was referred to a local orthopedic for follow up. At this time, the orthopedic felt an injection of 2cc Kenalog and a patellofemoral J brace would allow the individual to participate until season's end. When no symptomatic relief was provided by the injection, a second opinion was sought from another orthopedic surgeon. Following this evaluation in November 2010, the patient underwent an abrasion chondroplasty of the patella and removal of loose bodies. The patient did not return to basketball activities during the 2010-11 season. Two months following this surgery, symptoms returned. At this point, a conservative approach of non weight bearing activity and isometric quad strengthening was instructed from the physician to reduce symptoms. In May 2011, the patient began experiencing increasing pain and effusion upon all weight bearing activity. She was then referred to another orthopedic specialist for an osteochondral allograft transplantation. During this visit, June 2011, a final course of action was detailed for the patient in order to resume her intercollegiate athletics career. Initially, a surgery to debride the patella and removed loose bodies was performed. Visco-supplementation was then utilized during the Fall of 2011 to allow the patient to participate in basketball for the 2011-12 season. Following the basketball season in March 2012, a DeNovo allograft cartilage transplantation was performed. **Uniqueness:** Evidenced based outcomes of allograft cartilage transplantation in young and active patient populations are limited. Along with this, multiple factors such as BMI, defect size, pre-existing conditions, and length of elapsed time before the transplantation confound the problem for athletic trainers as they advise patients, parents, and coaches on courses of action for return to activity. **Conclusions:** The allograft transplantation was the only option available to allow the athlete to return to play prior to her eligibility to expire. As of this submission, the patient has been cleared to return to intercollegiate basketball for the 2012-13 season. She has experienced no setbacks. This case highlights the conundrum of evidenced based treatment and rehabilitation algorithms for athletic trainers managing osteochondral defects, particularly on the patellofemoral surface. Very little RCTs exist for younger and active populations. Athletic trainers would benefit from the knowledge of surgical protocol, graft failure rates, osteochondral hypertrophy, and osteoarthritis are all complications that are byproducts of surgery.

Comparison Of The Occurrence Of Response-Shift Among Sporting And Non-Sporting Autologous Chondrocyte Implantation(ACI) Patients

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Context: Response-shift is the phenomenon by which an individual's standards for evaluation change over time due to a change in internal standards, values, or construct definition. Response-shift has been observed in a variety of populations including knee arthroplasty and cartilage patients. Failure to account for response-shift may result in over or under-reporting treatment effects on health related quality of life(HRQL). The capacity to participate in sports greatly influences athletes' perceived HRQL. Whether athletes are more prone to response-shift following interventions that restrict physical activity has not been previously explored. **Objective:** Our purpose was to determine if patients undergoing ACI who reported high levels of sports participation experienced greater response-shift following ACI than non/low-level sports participants. It was hypothesized that those individuals who prospectively self-identified themselves as sporting would experience more response-shift due to the physical limitations imposed following ACI (restrictions in weight bearing, physical activity, etc.). **Design:** Case-control **Setting:** Orthopaedic Clinic **Patients:** Individuals undergoing ACI who self-identified as non-sporting (n=25, 34.6±7.1yrs, 92.6kg, 173cm) or as sporting (n=22, 35.6±9.2yrs, 92.0kg, 189.2cm). **Intervention:** All patients underwent ACI for the repair of symptomatic articular cartilage defects. The "Then-Test" method was used to evaluate response-shift in the following patient reported outcomes(PROs) – the SF-36 Physical Component Scale(SF-36PCS), the IKDC Subjective Knee Evaluation Form, and the Lysholm Knee Scale. Each PRO was completed pre-ACI and 6 and 12 months post-surgery. At 6 and 12 months an additional "then" version of each PRO was also completed. The "then" version was identical to the original except that patients were instructed to assess how they were pre-ACI. It is theorized that by completing the then-test and post-test PROs at the same time point the same frame-of-reference is utilized. **Main Outcome Measures:** Response-Shift (RS=then-score – pre-score) and Response-Shift Magnitude (RSM=|then-score – pre-score|) were calculated at 6 and 12 months. Independent t-tests were used to compare RS and RSM values between groups at 6 and 12 months. **Results:** There were no differences between groups for age, BMI, or defect size. There were no differences in RS at 6 or 12 months or in RSM at 6 months for any of the PROs. RSM at 12 months was greater in the sporting than non-sporting group for the IKDC (15.80±13.26 vs. 6.06±5.42, p=0.005), SF-36PCS (10.33±8.04 vs. 5.72±4.90, p=0.046), and Lysholm (16±14 vs. 8±5, p=0.029). **Conclusions:** These results suggest that sporting patients may recalibrate, reprioritize, or reconceptualize their personal definition of physical function during the first year following ACI. The failure to find a difference in RS values suggests that the response-shift experienced is not uniform in direction and varies from patient-to-patient. Future research is needed to determine if this variability in direction may be associated with expectations for surgery or intent to return to sports.

Knee Evidence-Based Forum

Wednesday, June 26, 2013, 10:30AM-11:30AM; Palm B; Moderators:

Shoulder Evidence-Based Forum

Thursday, June 27, 2013, 8:00AM-9:00AM; Palm B; Moderators:

Free Communications, Oral Presentations: Adaptations and Kinetic Chain in Pitchers

Thursday, June 27, 2013, 9:15AM-10:30AM; Palm B; Moderator: Jeffrey Cooper, MS, ATC

Excessive Glenoid Retroversion Is Associated With Increased Rotator Cuff Strength In The Shoulder

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Context: The rotator cuff muscles are critical secondary stabilizers in the shoulder. Increased glenoid retroversion has been associated with the risk of posterior shoulder instability; however, the impact of increased glenoid retroversion on rotator cuff strength remains unclear. **Objective:** To examine the association between glenoid retroversion and rotator cuff strength in the shoulder. **Design and Setting:** This study represents a cross-sectional analysis of baseline data from a prospective cohort study conducted at a US Service Academy. **Participants:** 574 college freshmen with no history of glenohumeral joint instability at baseline or during the 4 year follow-up period were included in the current study. The average age, height, and weight of participants was 18.77±0.97 years, 176.81±8.48 cm, and 73.80±12.45 kg, respectively. **Intervention/Methods:** Baseline data collected upon entry into the study included bilateral MRI assessments of glenoid version. All measures of glenoid version were performed by a musculoskeletal radiologist blinded to all other baseline data. Rotator cuff strength was also assessed at baseline using a hand held dynamometer. Internal and external rotation strength was assessed with the glenohumeral joint positioned in neutral and in 45º of abduction. **Main Outcome Measures:** The primary dependent variables of interest were the four measures of rotator cuff strength. The independent variable consisted of four levels based on quartile cut points for the degree of glenoid retroversion. Four separate one-way ANOVAs, along with Scheffe post-hoc tests, were used to examine mean between group differences in rotator cuff strength with shoulder as the unit of analysis. **Results:** We observed significant main effects for internal ($F_{3,1144}$=11.79, p<0.001) rotation strength in neutral. Scheffe post-hoc analyses demonstrated that internal rotation strength was significantly higher in subjects in the upper quartile (4Q:53.65±13.99) for glenoid retroversion when compared to those in the lower three quartiles (3Q:49.98±14.47, 2Q:49.09±13.04, 1Q:46.93±13.16), respectively. Similar main effects were observed for external ($F_{3,1144}$=9.62, p<0.001) rotation strength in neutral and internal ($F=13.66_{3,1144}$, df=3, p<0.001) and external ($F_{3,1144}$=15.70, p<0.001) rotation strength in 45º of abduction and post-hoc analyses demonstrated that all rotator cuff strength measures were significantly higher in subjects in the upper quartile for glenoid retroversion when compared to those in the lower three quartiles. No other significant between group differences were observed. **Conclusions:** Increased glenoid retroversion has been previously associated with acute posterior shoulder instability. The increased rotator cuff strength observed in those in the upper quartile for glenoid retroversion in the current study may represent an acquired compensatory mechanism in these secondary stabilizers of the glenohumeral joint.

The Acute Effects Of Hold-Relax Proprioceptive Neuromuscular Facilitation With Vibration Therapy On Glenohumeral Internal Rotation Deficit

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Context: Glenohumeral internal rotation deficit (GIRD) is believed to be a strong contributing factor to shoulder injuries in overhead throwing athletes. Clinicians use various stretching techniques to prevent the onset of and treat GIRD. It is unknown which stretching technique is the most effective treatment for GIRD. **Objective:** To compare the acute effects of hold-relax proprioceptive neuromuscular facilitation (PNF) with and without vibration therapy on glenohumeral internal rotation in individuals with GIRD. **Design:** Two-within (stretch x time) comparison. **Setting:** Controlled laboratory. **Patients or Other Participants:** Eleven male overhead and former overhead athletes (19.8±1.4 years, 184.5±4.5 cm, 91.8±11.6 kg) presenting with GIRD. **Interventions:** Participants reported for three separate sessions with a minimum of seven days between sessions. At each session, three pretest maximum passive glenohumeral internal rotation measurements were taken and averaged on the throwing dominant shoulder with a digital protractor. There was a 60 second rest between each pretest measurement. At each session, participants performed one of three randomly assigned stretches: hold-relax PNF (PNF), hold-relax PNF in combination with a whole body vibration unit set at 30 Hz (PNF-V) and static stretch (SS). All stretches involved a 30 second static stretch,

while the PNF and PNF-V stretches included a six second isometric contraction prior to the static stretch. Three trials were performed for each stretch with a 60 second rest between trials. Immediately after each trial, posttest maximum passive glenohumeral internal rotation measurements were taken and averaged with a digital protractor. The independent variables were stretch (PNF, PNF-V and SS) and time (pretest and posttest). **Main Outcome Measures:** The dependent variables were the mean glenohumeral internal rotation measurements taken at the pretest and posttest. The influence of stretch and time on mean glenohumeral internal rotation was compared using a 3x2 factorial ANOVA with repeated measures on both variables (*P*d"0.05). Tukey post hoc testing was applied in the event of a significant interaction. **Results:** There was a stretch-by-time interaction ($F_{2,20}$=34.697; *P*<0.001). Post hoc testing revealed that the PNF posttest (73.0±10.4°) was greater than the PNF pretest (60.0±11.8°), the PNF-V posttest (74.7±10.0°) was greater than the PNF-V pretest (57.4±10.4°), and the SS posttest (67.0±10.7°) was greater than the SS pretest (60.1±9.4°). When comparing the posttest values, the PNF-V posttest was greater than the SS posttest. **Conclusions:** All three stretches (PNF, PNF-V and SS) resulted in acute increases in glenohumeral internal rotation in individuals presenting with GIRD. The PNF-V stretch resulted in the greatest increase in glenohumeral internal rotation and was significantly more than the SS stretch. Utilization of hold-relax PNF with vibration therapy may be clinically beneficial for individuals with GIRD. Future research investigating the long-term effectiveness of these stretching techniques on glenohumeral internal rotation is warranted.

The Relationship Between Clinically Measured Hip Rotational Motion And Shoulder Biomechanics During The Pitching Motion

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Context: Throwing a baseball has been described as a kinetic chain of events that begins with the development of power in the lower extremity, which is then transmitted through the core and finally to the upper extremity prior to ball release. Although, many clinicians have hypothesized that altered motion at one segment in this chain can affect the forces placed on distal segments, little research has explored these relationships. **Objective:** To determine if alterations in hip rotational motion affect the amount of external rotation torque or horizontal adduction of the dominant shoulder developed during the throwing motion. **Design:** Cross-sectional. **Setting:** Athletic training room. **Participants:** Thirty-four, asymptomatic, NCAA Division I baseball pitchers (age=20±1.3 years; height=187.2±5.8 cm; mass=86.9±6.8 kg) participated. **Interventions:** We measured bilateral hip rotational ROM in a prone position using a digital inclinometer. We measured external rotation torque and maximum horizontal adduction motion of the throwing shoulder using a three-dimension, high speed video capture system. Separate multiple regression analyses were used to determine if relationships existed between hip external rotation ROM and external rotation torque produced at the throwing shoulder, as well as maximum shoulder horizontal adduction motion during the throwing motion (*p*<.05). **Main Outcome Measures:** Dependent variables included shoulder external rotation torque and maximum shoulder horizontal adduction motion during the throwing motion. **Results:** The averages and standard deviations for shoulder external rotation torque and shoulder horizontal adduction during the throwing motion were 5.1±1.0 % body weight x height and 21.0º±8.1º. The clinically measured lead leg internal, external, and total arc of rotational ROM were 27.7º±5.9º, 35.8º±3.4º, and 63.4º±7.0º. Trail leg internal, external, and total arc of rotational ROM were 28.9º±7.2º, 35.4º±6.2º, and 64.2º±8.4º. Multiple regression analyses showed that the total hip rotational motion of the lead leg measured clinically had a significant relationship with shoulder external rotation torque (*r*=.56, *P*=.003) during the throwing motion. Both lead leg hip external rotation (*r*=-.39, *P*=.02) and internal rotation (*r*=.42, *P*=.009) ROM made significant individual contributions to this relationship. Lead leg external rotation ROM had a significant negative relationship with shoulder horizontal adduction during the throwing motion (*r*=-.36, *P*=.04). The total rotational motion of the trail leg had a significant relationship with shoulder horizontal adduction motion (*r*=.43, *P*=.04). However, trail leg external rotation was the only significant contributor to this relationship (*r*=-.35, *P*=.04). No other significant relationships were noted (*r*<.37, *P*>.11). **Conclusions:** Our results demonstrate that altered hip rotational ROM measured clinically has a direct effect on the amount of dominant shoulder external rotation torque and horizontal adduction during the throwing motion. Because of these relationships clinicians should consider utilizing stretches, which target hip rotation ROM, in an effort to minimize the kinetic forces and excessive motion placed on the throwing shoulder.

Improper Trunk Rotation Sequence Is Associated With Increased Maximal Shoulder External Rotation Angle And Shoulder Joint Force During Baseball Pitching

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Context: In a coordinated throwing motion, peak pelvis rotation velocity is reached before the peak upper torso rotation velocity, so that angular momentum can be transferred effectively from the proximal (pelvis) to distal (upper torso) segment. Despite the fact that upper extremity kinematics and kinetics during throwing are highly influenced by trunk kinematics, the effects of proper vs. improper trunk rotation sequence on baseball pitching performance (ball speed) and upper extremity biomechanics linked to common pitching-related upper extremity injuries have not been investigated. Objective: To investigate the effects of trunk rotation sequence on ball speed and upper extremity kinematics and kinetics linked to injuries in high school baseball pitchers. **Design:** Cross-sectional study. **Setting:** Biomechanics laboratory. **Patients or Other Participants:** Seventy-three healthy high school baseball pitchers (dominance=57-right/16-left, age=15.5±1.2years, height =179.3±7.3cm, mass=72.7±9.8kg). Interventions: Three-dimensional kinematics of the pitching motion were captured using a motion capture system. The pitches were performed until at least 3 strike-pitches were captured. **Main Outcome Measures:** Timings of peak pelvis and upper torso rotation velocity (% pitching time = time from stride foot contact to ball release), maximal shoulder external rotation angle (MaxER), elbow extension angle at ball release (ElbEXT), peak shoulder proximal force, shoulder internal rotation moment, and elbow varus moment were calculated from the marker coordinate data. Subjects were considered to have a proper vs. improper trunk rotation sequence when the peak pelvis rotation velocity reached before vs. after the peak upper torso rotation velocity beyond the margin of standard error of measurement (±3.7% pitching time), respectively. Subjects in whom the difference in timing of peak pelvis and upper torso velocities was within the margin of error were excluded. Dependent variables were compared between groups using independent t-tests (˜<.05). Results: Subjects with improper trunk rotation sequence (n=33) demonstrated greater MaxER (mean difference=7.2°±2.9°, 95%CI =1.39°-13.0°, t_{54}=2.5, p=.016) and greater shoulder proximal force (mean difference=9.2±3.9%body weight, 95%CI=1.4-16.9%, t_{54}=2.4, p=.021) compared to those with proper trunk rotation sequence (n=23). There were no group differences in ElbEXT, ball speed, or the other joint kinetic variables (p>.05). **Conclusions:** No significant difference observed in ball speed or joint moments suggest that other factors may have a larger influence on these variables. Anatomically, the greater MaxER is associated with increased risk of posterior impingement and superior labral anterior-posterior lesion. Additionally, increased shoulder proximal force that resists distraction of the shoulder during arm-acceleration is linked to increased tensile stress on the rotator cuff and biceps-labral complex. Therefore, improper trunk rotation sequence may be harmful to the throwing shoulder. Methods to identify pitchers with improper trunk rotation sequence without a motion capture system, and to correct the improper technique need to be investigated in order to apply this observation to prevention of pitching-related upper extremity injuries.

Effects Of A Sport Specific Training Program Targeting The Pelvis, Spine And Trunk On Throwing Velocity And Muscular Power And Endurance Measures In College Throwing Athletes

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Context: The ability to stabilize and actively control the pelvis, spine and trunk, has been reported to influence sport performance yet there is limited evidence supporting that improvements in sport result from changes in the muscles supporting the pelvis, spine and trunk. Traditional interventions lack sport specific methods which target both the muscular power and endurance capabilities of the pelvis, spine, and trunk. Objective: To investigate the effect a traditional endurance training program and a sport specific power training program have on throwing velocity, muscular endurance and power measures of the proximal segments. We hypothesized there would be a significant difference (p d•.05) in change scores for throwing velocity, muscular power and muscular endurance between groups. Design: A randomized clinical trial with blocked stratification for sex and position was implemented with a pre- to post-intervention design. Setting: Field and research laboratory. Patients or Other Participants: Forty-six healthy (mean age = 20 ± 1.3 years, height = 175.7 ± 8.7 cm, weight = 79 ± 13.9 Kg), Division III collegiate female softball (n=17) and male baseball (n=29) players from the same institution volunteered and were randomly assigned to one of two training groups for 7 weeks; a traditional endurance training group (ET) (n=21) or a power training group (PT) (n=25). Interventions: The ET group performed a traditional endurance progression relative to the number of repetitions and time incorporating static and linear exercise movements of the pelvis, spine and trunk. The PT group received undulating blocked periodization consisting of endurance, strength and power movements specific to throwing. Main Outcome Measures: Peak throwing velocity (km/h) normalized for body weight (kg), muscular endurance prone plank tests (seconds) and power output from a one-repetition maximum chop test (watts/Kg body weight) were measured pre- and post- intervention. Student's independent t-tests were used to compare differences between the change score for all dependent variables with alpha level set at pd".05. **Results:** The peak throwing velocity change score was significantly faster by 6±2% in the PT group (ET= .01±.1 km/h/kg of body weight, PT= .08±.03 km/h/kg of body weight, p< .001) at post-intervention compared to the ET group. Muscular endurance was not different between groups (ET= 154 ±54, PT= 151±42, p= .901). The power chop test improved in PT group (105 ±68 watts) compared to the ET group (20 ±78 watts) (p<.001) **CONCLUSION:** This is the first study to demonstrate improvements in muscle performance for the proximal segments simultaneously with a sport performance measure in throwing velocity. Sport specific training that targets the pelvis, spine and trunk is beneficial to muscular power measures and throwing performance. KEYWORDS: Spinal Stability; Core Stability, Exercise Training, Performance Assessment

Inter-Rater Reliability Of The Movement And Activity In Physical Space (MAPS) System: Geospatial Functional Outcome Measures

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Context: Functional outcome measures are critically important for evaluating the effectiveness of clinical treatments and tracking disease progression. The measures currently used in clinical settings are unable to account for factors, such as environment, that can influence function. In an attempt to address this measurement issue, we have developed and validated the Movement and Activity in Physical Space (MAPS) system, which combines physical activity and geospatial data, providing an assessment of real-world function across multiple days. **Objective:** To examine the inter-rater reliability of the MAPS system variables. **Design:** Observational. **Setting:** Laboratory. **Participants:** Two teams of 2 raters, all trained in MAPS processing and currently using MAPS system in other projects, volunteered for this study. **Interventions:** The raters processed 6 days of MAPS data from a past project. The 6 days of unprocessed MAPS data were chosen from 3 individuals for data processing based on the difficulty and complexity in processing with 2 days simple/light travel, 2 moderate days, and 2 complex/extensive travel days. These data had participants wear an ActiLife GT3X+ accelerometer on the non-dominant hip and clipped a GPS receiver to their belt during all waking hours except when bathing. Each team processed the 6 days of data to extract the 11 MAPS system variables. **Main Outcome Measures:** The 11 MAPS system variables were total physical activity counts (TPAC), total physical activity counts at home (TPACH), total physical activity counts at locations other than home (TPACL), total step counts (TSC), total step counts at home (TSCH), total step counts at locations other than home (TSCL), total time at home (TTH), total time at locations other than home (TTL), total number of trips away from home (TL), total number of instrumental trips (IT), and total number of discretional trips (DT). Each team examined the same 6 days of unprocessed MAPS data and calculated each of the MAPS system variables for each day. Inter-rater reliability was examined by calculating interclass correlation coefficients (ICC 3,1) for each of the 11 variables. An ICC of .7 was considered acceptable and an ICC of .8 or greater considered good. **Results:** The ICCs for most of the MAPS variables were considered good with TPAC=.98; TPAL=.99; TPAH=.96; TSC=1.0; TSL=.99; TSH=.97; TTL=.78; TTH=.74; TL=.98; IT=.92; DT=.82. **Conclusions:** Overall, the rating teams produced very good inter-rater reliability for 9 MAPS variables with acceptable ICCs for TTH and TTL. These time variables are related to one another and future procedural work should be done to reduce the error. The results support multiple rating teams to be able process and combine data, which will allow for larger MAPS studies to be conducted at multiple sites.

Comparison Of Standard Goniometry Versus An Iphone Goniometry Accelerometer Application To Measure Knee Flexion And Extension

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Context: Measuring range of motion (ROM) is standard practice when conducting an injury evaluation. ROM is quantified using a standard goniometer (SG); but due to technological advances, alternative methods using iPhone applications may offer clinicians a quick, more efficient tool. **Objective:** To compare the relationship between knee flexion (KF) and extension (KE) active ROM (AROM) using SG and the iPhone application, Goniometer (App). **Design:** Quasi-experimental. **Setting:** Athletic training laboratory. **Participants:** Forty-one participants, 16 males and 25 females (age =20.5±1.1; height =171.4 cm±8.4cm; mass= 73.9kg±16.51) free of lower extremity injuries, surgery or pain for 6 months to the dominant limb participated. **Interventions:** Participants were placed supine for a single session measurement of KF and KE AROM by two independent raters using the dominant limb (used to kick a ball). To control measurement error, a polyvinyl chloride (PVC) frame was placed at the pelvis to maintain a 90° hip angle. Measurements were counterbalanced to control effect bias. Standard goniometric AROM was assessed using commonly reported landmarks; lateral epicondyle (axis), long axis of femur (stationary arm), and long axis of fibula (moveable arm). To measure AROM subjects maximally flexed and extended the knee while maintaining a 90° hip angle.

iPhone App (Goniometer, Jinfra) landmarks included; quadriceps tendon 1" proximal from superior patella pole (position 1), and along anterior tibia 1" distal from tibial tuberosity (position 2). Once maximal joint movement was obtained, the iPhone was placed horizontally along position 1. "Start" was pressed to measure position 1. This was repeated for position 2 with "End" pressed in order to calculate. Person Product Moment Correlation Coefficients were calculated to determine the relationships between KF and KE SG and the App. An intraclass correlation ($ICC_{2,1}$) measured KF and KE inter-rater reliability. **Main Outcome Measures:** SG and App KF and KE AROM measured in degrees. **Results:** Combined SG and app mean (SEM) rater scores for KE were 30.5° (1.6°) and 18.6° (1.7°), respectively. Combined KF rater mean (SEM) scores for SG and app were 135.7° (.89°) and 128.6° (1.8°), respectively. Significant relationships were also found between combined rater SG and app for KE, r (39) = .848, P = .000 and KF, r (39) = .502, P = .001. ICC measurements for inter-rater reliability values for KE and KF were .805 (95% CI: .663 to .891) and .318 (95% CI: .015 to .567), respectively. **Conclusions:** A significant relationship between SG and the App suggests that the iPhone App may be an option for assessing KF and KE AROM; however inter-rater reliability demonstrated poor to moderate reliability between raters. Due to poor inter-rater reliability the iPhone Goniometer app should be avoided when different clinicians are measuring a patient's ROM.

A Comparison Of Standard Goniometry Versus Drgoniometer Ipad/Iphone App For Measuring Knee Flexion And Extension

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Context: Range of motion measurements are commonly used by clinicians when conducting a physical examination, traditionally assessed using a goniometer. However, standard goniometry (SG) measurements have demonstrated inconsistent and sometimes unreliable results prompting clinicians to search for alternative methods of consistently assessing ROM such as through the use of iPad/iPhone applications. **Objective:** To compare the relationship between knee flexion (KF) and extension (KE) active ROM (AROM) using SG and the iPad/iPhone paid application DrGoniometer (app). **Design:** Quasi-experimental. **Setting:** Athletic training laboratory. **Participants:** Forty-one participants, 16 males and 25 females (age=20.5±1.1; height=171.4 cm±8.4 cm; mass=73.9 kg±16.51) free of lower extremity injuries, surgery/pain for 6 months to the dominant side. **Interventions:** Participants were placed supine for a single session measurement of KF and KE ROM by two independent raters using the subjects' dominant leg (used to kick a ball). To control measurement error, a polyvinyl chloride (PVC) frame was placed at the pelvis to maintain a 90° hip joint angle. Measurements were counterbalanced to control effect bias. Standard goniometric AROM was assessed using commonly reported landmarks; lateral epicondyle (axis), long axis of femur (stationary arm), and long axis of fibula (moveable arm). Subjects then maximally flexed and extended the knee while maintaining a 90° hip joint angle to collect AROM. The app landmarks included; lateral epicondyle (axis), greater trochanter (stationary arm), and lateral malleolus (moveable arm). Once maximal joint movement was obtained a digital photograph using the iPad/iPhone app was recorded. The app automatically calculated ROM by manually manipulating three markers so a red circle with a cross inside was placed on the anatomical landmarks identified above. To ensure proper positioning the app provided a red dotted line that connects the individual reference points to ensure proper alignment. Person Product Moment Correlation Coefficients were calculated to determine the relationship between KF and KE SG and the app. An intraclass correlation ($ICC_{2,1}$) measured KF and KE inter-rater reliability. **Main Outcome Measures:** KF and KE AROM measurements for SG and app measured in degrees. **Results:** Combined SG and app mean (SEM) rater scores for KE were 30.5° (1.6°) and 28.9° (1.6°), respectively. Combined KF mean (SEMS) scores for SG and app were 135.7° (.89°) and 136.7° (.91°), respectively. Significant relationships were found between combined rater SG and app for KE, $r(39)$=.907, P=.000 and KF, $r(39)$=.865, P=.000. ICC measurements for inter-rater reliability values for KE and KF were .785 (95% CI: .631-.879) and .877 (95% CI: .781-.933), respectively. **Conclusions:** A significant relationship existed between SG and the Dr.Goniometer app suggesting that the application may be a viable option for assessing knee AROM. The Dr.Goniometer app is a quick and easy tool that allows for long-term data storage and may help improve patient motivation.

Accuracy Of On-Person GPS Units In Tracking Static And Dynamic Movement In Patients

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Context: The use of GPS units is more common in athletic training to track functionality post-injury. The accuracy of tracking individuals has not been fully substantiated although we have established validity evidence in post-surgical knee patients. **Objective:** To determine the accuracy of GPS units in participant-tracking research. **Design:** Observational study**. Setting:** Free-living environment. **Patients or Other Participants:** Three GPS readings of National Geodetic Survey (NGS) benchmarks and 3 different units tracked participant movement on 84 corners of 21 rectangular art installations in the campus Bicentennial Park to test the accuracy of GPS data. **Interventions:** Two types of movements were tracked to test the accuracy of GPS units: static and dynamic. NGS were used for static movements with extremely accurate locations using markers to compare the accuracy of GPS units with respect to the known locations of the benchmarks. The dynamic movements were tracked following specific patterns whose locations are known. **Main Outcome Measures:** The GPS units have some error but it has not been established for static and dynamic measures. The units offer a great method for tracking individual functionality in non-laboratory settings. The efficacy must be explored. ArcGIS, a mapping software, was used to track the data and offer spatial analysis of the GIS data. The NGS benchmarks offer the static measures of the GPS units. For dynamic movement, ArcGIS was used to pinpoint known locations and the error of the GPS units was cited. **Results:** All dedicated GPS units were relatively similar in terms of the magnitude of the true and relative errors at most static sites. True errors for the Land Air Sea (LAS) GPS device ranged 2-7m and relative errors from 4-10m. Interestingly, the least accurate readings were for the urban sites that were in close proximity to buildings. The error of the units for the dynamic tracking are as follows, starting with mean and followed by standard deviation: Garmin Oregon with WAAS enabled (high priced market item) 2.13m and 1.18. There were two LAS GPS used in the study and their descriptive statistics are as follows: mean = 3.74m and standard deviation = 2.52; mean = 3.74m and standard deviation of 1.52. **Conclusions:** On a global scale, accuracy within 3.5m is a well-performing GPS measure. On a smaller scale, 3.5m should be able to help distinguish between an individual's locations. The efficacy of the LAS (3.5m accuracy), a cheaper and comparable version to the high performance Garmin Oregon (2.13m accuracy), can be used sufficiently to track an individual's position during the course of the study. The cost effectiveness of the Garmin Oregon is not worth the greater accuracy it offers. The LAS GPS units will sufficiently complete the task of tracking participant movement.

Test-Retest Reliability Of The Stability Evaluation Test Of The VSR™-Sport In A Pediatric Sample

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Context: The Stability Evaluation Test (SET) of the Neurocom® VSR™-Sport has been introduced as a clinical measure of balance, particularly for youth who have suffered a sport-related concussion (SRC). The SET requires the participant to complete the Balance Error Scoring System (BESS) protocol while on the force plate; however, instead of a rater measuring errors (as in the BESS), the force plate measures changes in center of gravity (or sway velocity) providing a more objective measure of impairment. Although clinically acceptable test-retest reliability has been established for the BESS, test-retest reliability has not been established for the SET protocol in a pediatric sample. **Objective**: To examine test-retest reliability of the SET protocol of the VSR™-Sport in a pediatric sample using clinically relevant timeframes and to investigate gender and age group differences on test-retest reliability in this sample. **Design**: Repeated Measures Design. **Setting**: Boys and Girls Club of Brookings. **Patients or Other Participants**: Fifty–four healthy children (33 males and 21 females, age=8.2±1.9yr; height =131.5 ±12.5cm; weight=31.4±11.1 kg) free from injury or illness known to affect balance completed all three testing sessions. **Interventions**: The SET protocol consists of 6 conditions lasting 20 seconds each (3 hard and 3 soft surface stances). Participants completed the SET three times over the course of 35 days: day 1, day 30 and day 35. The testing series represents points of clinical management following SRC. **Main Outcome Measures**: Sway velocity

(deg/sec) of each condition and a composite of the SET was measured at day 1, day 30 and day 35. An interclass correlation coefficient (ICC) was used to calculate test-retest reliability for three testing timeframes (Day 1-Day 30, Day 30-Day 35, Day 1-Day 35). ICC's were also calculated to determine test-retest reliability for gender and age group (younger cohort (5-7yr) and older cohort (8-15yr)). **Results**: Each testing timeframe elicited clinically acceptable (greater than .80) test-retest reliability for composite SET scores: Timeframe 1ICC=.91 (.84-.95, 95% CI), Timeframe 2 ICC=.92(.86-.95, 95% CI) and Timeframe 3 ICC=.86 (.76-.92, 95% CI). Although some variation existed in test-retest reliability when comparing males to females and a younger cohort to an older cohort, all ICC's demonstrated clinically acceptable findings. **Conclusions**: Strong test-retest reliability is necessary to ensure that impairments defined post-concussion are due to the condition, and not unreliable tests. Findings support strong test-retest reliability of the SET in a healthy pediatric sample when delivered over timeframes following current concussion management protocols. Although some variation in reliability exists when gender and age group are considered separately, reliability remains clinically acceptable. The ability to measure sway velocity rather than balance errors allows for an objective measurement of balance over time.

Validation Of Postural Stability Assessment Using Accelerometer And Gyroscopic Measures

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Context: Field experts have called for an objective assessment of postural stability to be included as part of a comprehensive concussion management program. However, the balance assessment most commonly utilized in the management of athletes with concussion, the Balance Error Scoring System (BESS), suffers from floor and ceiling effects in addition to poor inter- and intra-rater reliability. Conversely, sophisticated measures of postural stability such as the Sensory Organization Test lack the portability and accessibility for widespread in-field use. **Objective:** The objective of this project was to develop and validate a reliable, portable, and cost-effective method of objectively quantifying postural stability as part of the Cleveland Clinic Concussion (C^3) Application for the comprehensive assessment of concussion-related impairments. **Design:** A prospective longitudinal study was utilized. **Setting:** The validation study was conducted in the Neural Control Research Lab at the Cleveland Clinic. **Participants:** A volunteer sample of 49 high school and college-age students (14-25) participated in the study. Participants were not eligible if they had a history of concussion within the past 6 months or had any musculoskeletal or neurologic condition resulting in impaired balance. **Interventions:** Participants completed the entire Sensory Organization Test (SOT) consisting of three 20-second trials for each of the six conditions. Simultaneously, accelerometer and gyroscopic data were collected with the iPad2 affixed to the participant's sacrum with a standard weight-lifting belt. The transmission of data from the iPad2 was synchronized with the NeuroCom system to ensure temporal alignment of data collected by the two systems. **Main Outcome Measures:** Anterior-Posterior (AP) measure of postural stability was calculated using data from the accelerometer and gyroscope native to the iPad2, and validated against AP equilibrium scores calculated during simultaneous performance of the NeuroCom Sensory Organization Test. A bivariate correlation analysis was completed between the NeuroCom Equilibrium Scores (ES) and iPad2 Equilibrium Scores for each of the six conditions and for the Composite ES. Results: Equilibrium Scores as calculated from accelerometer and gyroscopic data from the iPad2 correlated significantly with NeuroCom equilibrium scores in each of the six SOT conditions ($r=0.44$ to 0.93; $p<0.01$) as well as the composite equilibrium score ($r=0.95$; $p<0.01$). **Conclusions:** Accelerometer and gyroscopic data from the iPad2 provide an accurate and objective measure of postural stability that could be used in the objective assessment of balance. This consumer electronics device is ideally suited to be used in clinical and sport environments to provide a portable method of balance assessment, and can be included as part of a comprehensive concussion management program.

Validation Of Accelerometry As A Physical Rest Monitor During Concussion Recovery

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Context: Current concussion guidelines call for physical and cognitive rest after sustaining a concussion. Patient compliance with these recommendations relies on subjective patient reports. There is little research into monitoring patient compliance with physical and cognitive rest in the free living environment. To better treat concussed athletes and evaluate these guidelines objective monitoring measures are needed. Accelerometry is applied in studies to track an individual's physical activity (PA) level using activity counts and has been validated in various PA trials. It has the potential to monitor adherence to physical rest (PR) following a concussion. **Objective:** To validate the use of accelerometry in monitoring patient compliance with PR following a concussion. **Design:** Observational matched-pair design. **Setting:** Free-living conditions. **Patients or Other Participants**: A total of 14 participants, (mean age: 19.8±1.0 yrs; females n= 7, males n= 7) DI and DIII collegiate varsity or club sport athletes volunteered for the study (concussed group (n=7) and control group (n=6); one control was removed for non-compliance). Matched controls were uninjured teammates. **Interventions:** The independent variable was group membership (concussed or matched-control). Participants wore an Actigraph GT3X+ accelerometer on the hip during waking hours, carried an on-person GPS device, and completed an activity diary for 5 days after concussion diagnosis. All concussed participants followed a concussion protocol recommending physical and cognitive rest. Matched-controls were monitored during the same time period. Independent t-tests (˜= 0.05) with Bonferoni adjustments were used to determine differences in PA between the concussed and control groups. **Main Outcome Measures**: The dependent variables (per day) were mean total PA counts, mean PA counts away from the home, mean PA counts at home. The amount of time spent away from home, and the total number of trips travelled were examined to ensure travel behavior was similar across groups. **Results:** There was a significant difference in mean total PA counts ($t(11) = 2.9$; $p<0.05$) between concussed athletes (Mean±SD: 298,158±116,704 counts) and controls (450,271±67,130 counts.) There was a significant difference in PA counts ($t(11) = 2.5$; $p<0.05$) between concussed athletes (224,661±100,306 counts) and controls (104,201±66,297 counts). There was no significant difference in PA at home ($t(11)= 0.522$; $p>0.05$) between concussed athletes (70,129±43,193 counts) and controls (58,609±34,962 counts). There was no significant difference regarding the amount of time spent away from the home ($t(11)=-0.9$; $p>0.05$) or the number of trips travelled ($t(10)=-0.1$; $p>0.05$) (concussed 465±79 min, 4.4±1.3 trips, control 472±166 min, 4.5±0.8 trips). **Conclusions:** Accelerometry is sensitive to PA changes associated with PR recommendations during concussion recovery. The change appears to be related to activities away from home. The travel patterns and activity at home was not altered. This provides validity evidence for the use of accelerometry in monitoring adherence to PR protocols for concussed athletes.

Objective Assessment Of Function Following Head Injury Using Movement And Activity In Physical Space (MAPS) Scores

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Context: Current concussion measures focus primarily on measuring patient impairments, are clinic-based tests (ie, neurological exam in front of a computer), and do not evaluate overall patient function. The Movement and Activity in Physical Space (MAPS) system can provide an objective measure of overall function in free-living environment by using accelerometry, on-person global positioning system (GPS) device, and geographic information systems (GIS). The MAPS system has been validated in post-surgical knee patients. **Objective:** To establish validity evidence for MAPS scores as objective measures of function in concussion patients. **Design:** Observational repeated measures matched-pair design. Setting: Environmental free-living conditions. **Patients or Other Participants:** A total of 14 university athletes (n = 7 concussed, n = 7 healthy control; aged: mean ± SD, 19.7±1.0yrs) participated in this study. The healthy controls were matched for age, sex, sport, perceived physical activity level, and major. Interventions: Participants wore an Actigraph GT3X+ accelerometer on their hip and an on-person GPS receiver for up to 10 days except for when sleeping or bathing. These devices measure activity counts (intensity), and step counts (volume) each minute and location (latitude/longitude). GPS data were verified by participants through the use of self-reported travelogues. MAPS scores were calculated by combining data from the GPS and accelerometer for

each day to assess patient function. Participants also completed daily symptom questionnaires. Main Outcome Measures: The dependent variables were 6 scores: MAPS intensity ($MAPS_I$), MAPS volume ($MAPS_V$), total symptom load, symptom severity, symptom "bothersomeness", and symptom frequency. Convergent validity evidence for MAPS was assessed using Pearson correlation (˜ = 0.05) examining the relationship between MAPS scores and self-reported symptom scores. Known-group difference validity evidence was assessed using independent t-tests (˜ = 0.05) evaluating differences in mean $MAPS_I$ and $MAPS_v$ scores between the concussion and control groups. **Results:** The $MAPS_I$ and $MAPS_V$ scores and self-reported symptom scores were significantly correlated with total symptom load (r = -0.32; p = 0.01, r = -0.33; p = 0.01), symptom severity (r = -0.30; p = 0.02, r = -.31; p = 0.01), symptom "bothersomeness" (r = -0.32; p= 0.01, r = -0.32; p = 0.01), and symptom frequency (r = -0.32, p= 0.01; r=-.31, p = 0.01), respectively. There was no significant differences (t_{12} = -1.11, p =.29: t_{12} = -0.36, p =.73, between the concussion (M±SD; $MAPS_I$ 1,523.4±1,068.9; $MAPS_v$ 46.0±40.0) and control groups (M±SD; $MAPS_I$ 2,231.8±1,314.4; $MAPS_v$ 50.3±25.0). **Conclusions:** Our correlation results provided evidence of convergent validity for MAPS scores in a concussion population during recovery. Although there were no significant group differences the data did show the expected inverse relationship between function and symptoms in all 4 symptom measures. Additional validity evidence to support the use of MAPS scores is needed.

Free Communications, Oral Presentations: Socialization, Retention and Work-Life Balance

Thursday, June 27, 2013, 3:15PM-4:45pm; Palm B; Moderator: Sara Nottingham, EdD, ATC, CSCS

Programmatic Factors Associated With Athletic Training Student Retention Decisions

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Context: Athletic training education programs (ATEPs) are charged with meeting an increased demand for athletic trainers with adequate graduates. Currently, it remains unknown what the retention rate is for ATEPs nationwide and what programmatic factors are associated with the retention rates of athletic training students (ATSs). Objective: Determine the retention rate for ATSs nationwide and the programmatic factors associated with ATS retention. **Design:** Cross-sectional online questionnaire. **Setting:** Undergraduate ATEPs. **Patients or Other Participants:** Program directors (PDs) of all Commission on Accreditation of Athletic Training Education (CAATE) accredited undergraduate ATEPs were asked to complete an online questionnaire. We obtained responses from 177 out of the 343 PDs (51.6%). The majority of respondents represented ATEPs at publicly funded (50.3%) Master's institutions (47.5%) with small enrollments (1000-3000 students) (26.6%) and predominantly National Collegiate Athletic Association Division 1 sponsored athletics (42.4%). The ATEPs represented had been accredited for 10.7±4.0 years and required 2.8±0.6 academic years of clinical education. Program directors admitted an average of 16.0±13.9 students into the ATEP annually, most doing so after completion of two semesters of coursework (51.4%). The program directors held their positions for 8.0±6.0 years. Interventions: An online questionnaire, developed based upon the current literature, was sent to all PDs of CAATE accredited undergraduate ATEPs. We asked them for demographic and factual information about their institution, ATEP, and themselves. We pilot tested the questionnaire on three separate occasions to reduce measurement error and provide construct validity. **Main Outcome Measures:** We asked the PDs to identify the percentage of ATSs who graduated from their ATEP out of the total number of ATSs admitted into their ATEP over the past 5 years. We used multiple regression to evaluate the ability of the demographic and factual variables to predict the ATS retention rate. **Results:** The participants reported an average retention rate of 81.0±17.9% (range=9%-100%). We found a significant prediction equation ($F_{4,167}$=16.39, R^2=0.282, P<0.001) using the timing of formal admission into the ATEP (P<0.001, R^2=0.162), the number of years the ATEPs had been accredited (P<0.001, R^2=0.068), the number of students admitted to the ATEP annually (P<0.01, R^2=0.032), and the number of years the PD had held their position at their current institution (P=0.04, R^2=0.019). **Conclusions:** We believe that delaying the formal admission of prospective students may aid professional socialization allowing ATSs to make an informed decision to enter an ATEP. We also believe ATEPs with a rich history of success and consistent leadership can provide an environment that fosters ATS retention. Program directors should carefully consider how many students to admit into the ATEP annually as individual attention from faculty, staff, and clinical preceptors may alter persistence decisions of ATSs.

Work-Life Balance In The Division I Clinical Setting From The Perspective Of The Head Athletic Trainer

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Context: Work-life balance (WLB) has been examined in the collegiate level from multiple perspectives, expect for the athletic trainer (AT) serving in a managerial or leadership role. Evidence suggests those in supervisory roles can help facilitate WLB for their employees, yet little is know about the challenges they face individually due to their role. **Objective:** Investigate challenges with WLB faced by the Head AT and strategies used in achieving WLB. **Design:** Qualitative study using structured interviews. **Setting:** Web-based management system. **Patients or Other Participants:** Eighteen total Head ATs (13 males, 5 females) volunteered to participate in our asynchronous, online interview. The average age of the participants was 44 years ± 8 and they had on average 22 ± 7 years of experience. Of the 18, 15 (83%) were married/partnered and 3 (17%) were single. Eight of 17 (44%) were married with children. Only one of our Head ATs did not have travel duties associated with their job responsibilities. **Data Collection and Analysis:** Participants responded to a series of questions by journaling their thoughts and experiences. We included multiple analyst triangulation, stakeholder checks, and peer review to establish data credibility. We analyzed the data via a general inductive approach. **Results:** Two higher order themes emerged from our analysis of the data to speak of the individual experiences of the Head AT: 1) *Organizational challenges* and 2) *WLB strategies*. The *Organizational Challenges* theme portrays the factors causing issues with WLB for the Head AT and contained 2 lower order themes: 1) lack of autonomy and 2) role demands. The WLB strategies theme included those strategies employed personally by the Head AT to promote WLB and contained 3 lower order themes: 1) prioritization of commitments, 2) strategic boundary setting and 3) work-family integration. Four additional themes emerged from the data regarding methods used by Head ATs to promote WLB amongst their staff members: 1) modeling WLB, 2) encouraging disengagement from the AT role, 3) cooperation and community workplace, and 4) administrative support and understanding. These four themes address the leadership role assumed by the Head AT and their use of informal strategies to encourage WLB. **Conclusions:** Head ATs are susceptible to experiencing work-life imbalance, just like those ATs in non-supervisory roles. The causes, although not avoidable, are manageable. Head ATs are encouraged to prioritize their personal time and make efforts to spend time away from their demanding positions as well as reduce, when possible the number of additional responsibilities that can impede upon time available to get away from work. Furthermore, Head ATs are advocates for WLB and are making efforts to help their ATs fulfill WLB by modeling the concept themselves, as well as promoting a cohesive and supportive work environment.

Managing Motherhood In The NCAA Division I Setting: The Role Of Mentorship And Female Athletic Trainers

Barone CM, Mazerolle SM, Ferraro EM, Goodman A: University of Connecticut, Storrs, CT, and Appalachian State University, Boone, NC

Context: One of the greatest catalysts for turnover in the profession among women is motherhood, especially if employed at the Division I collegiate level. We know that the medical education literature regularly identifies the importance of role models in value, attitude, and professional character formation. However, there is very limited research examining the role of mentorship and professional role models as it relates to female athletic trainers' (FATs) perceptions of motherhood and retention. **Objective:** To evaluate perceptions of motherhood and retention in relation to mentorship and role models amongst FATs currently employed in the collegiate setting. **Design:** Structured, online asynchronous interviews. **Setting:** Female BOC certified ATCs working at the Division I setting. **Patients or Other Participants**: 27 FATs (single=14; married=6; married with children=7) employed in the NCAA Division I setting volunteered. Average age of the participants was 34 ± 8. All were full-time BOC certified with an average 11 ± 7 years of clinical experience. **Data Collection and Analysis:** Participants responded to a series of questions by journaling their thoughts and experiences via QuestionPro™. Multiple analyst triangulation and peer review were included as steps to establish data credibility. The data was analyzed borrowing from the principles of general inductive approach. **Results:** The first theme, *impact of role models/mentors*, highlights the capacity of a male or female role model

to positively or negatively influence career and WLB perceptions of women working in the Division I setting. The second theme *desire for female role models/mentors*, speaks to the participant's desire to see more women in the profession handle the demands of motherhood and the demands of a taxing clinical setting. Women who have had female mentors are more positive on the prospect of balancing the rigors of motherhood and the demands of their jobs. Our FATs who did not have a female mentor, yet wanted one were apprehensive about their longevity in the field of athletic training, because of motherhood. **Conclusions:** Similar to previous research it appears as though the prospect of raising a family and balancing the demands of Division I seem daunting for most women. However, mentorship/role models are a valuable tool for perseverance in the profession and at the highly demanding clinical settings. Our results coincide with research in other medical professions, identifying the importance of role models on females. As more FATs remain in the profession who are able to maintain work-life balance and are available to serve as role models, it is conceivable that the attitudes of other women may start to change. Future inquiry should examine the impact of role models at clinical settings outside of Division I and ways to increase role model exposure to female athletic trainers.

Retention And Attrition Factors For Male Athletic Trainers In The National Collegiate Athletic Association Division-I Setting

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Context: Social support, autonomy, and job satisfaction are among the factors influencing female athletic trainers' (ATs) decision to persist in the National Collegiate Athletic Association Division-I (NCAA D-I) setting, while work-life balance issues and role overload are factors leading them to depart. These factors may not be similar for male ATs. **Objective:** Gain insight into the factors which affect male ATs' decisions to persist at or depart the NCAA D-I setting. {Banerjee, 2004 #30}**Design:** Qualitative study. **Setting:** NCAA D-I institutions. **Patients or Other Participants:** A total of 19 current (n = 11) and former (n = 8) employees participated in our study. The current employees averaged 6 ± 6 years of NCAA D-I clinical experience, 66 ± 10 working hours per week during the traditional sport season, and 34 ± 5 years of age. The former employees averaged 15 ± 11 years of NCAA D-I experience, 66 ± 5 working hours per week during the traditional sport season, and 45 ± 11 years of age. **Data Collection and Analysis:** Data were collected via in-depth, semi-structured interviews, and transcribed verbatim. Two researchers followed the steps of a grounded theory study and analyzed data independently. Data saturation guided recruitment, while a peer review and member checks established credibility. **Results:** Two main persistence themes emerged from the data: 1) D-I atmosphere and 2) workplace environment. The level of collegiality and support along with an exciting and competitive atmosphere were reasons for persistence. Four departure themes emerged from the former employee data: 1) role strain, 2) work-family conflict, 3) role transition, and 4) lack of advancement. The role strain theme contained 2 subthemes; role conflict and role overload. The lack of advancement theme also contained 2 subthemes; lack of promotion and lack of compensation. Male ATs experienced role overload and role conflict that created an imbalance between work and family. A lack of promotional chances and low salaries were implicated as reasons to depart their role. For those with more years of service, taking an opportunity to reduce one's responsibilities and move toward retirement were common departure strategies. **Conclusions:** Our findings regarding reasons to persist or leave the NCAA D-I setting are comparable to those within the literature. Issues with salary, career advancement and role transition are not unique attrition factors, but have not been found among female ATs. Unique to the profession is the competitive atmosphere which is satisfying for many ATs and influenced persistence. Future research needs to examine the career intentions of ATs, regardless of gender as well as the satisfaction of those ATs who depart the profession to determine if a career/setting change mitigated their concerns.

Perceptions Of Retention Indicators In Athletic Training

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Context: Attrition in the profession of athletic training notably occurs in large numbers between five and ten years of work experience creating a profession dominated by young, entry-level practitioners. Theoretical constructs are currently used to explain the retention issues in athletic training, yet an assessment of individuals who have left the profession is lacking. **Objective**: To assess reasons why athletic trainers let their athletic training certification (AT-C) lapse and leave the athletic training profession. **Design**: Cross sectional-observational study. **Setting**: Internet Survey. **Patients or Other Participants**: We recruited 1000 former certified athletic trainers who let their certification lapse within the past 5 years. Eighty-four of the 1000 email addresses were undeliverable leaving 916 viable participants with198 respondents for a 22% response rate. **Interventions**: We administered the survey online and determined face/content validity with a review of three certified athletic trainers (experience range 12±8 years), factor analysis, and strong indication of internal consistency (Cronbach's alpha=0.98). **Main Outcome Measures**: The survey consisted of 18 questions, including 9 demographic questions, 7 matrices regarding aspects of retention, and two open-ended questions to assess coping strategies. The matrices employed 5-point Likert scales to measure agreement (1=strongly disagree to 5=strongly agree. We used a Kruskal-Wallis to assess work/family issues. We assessed gender, age, relationship status, employment setting, highest education level, and children on three constructs identified in the factor analysis: work/family, work-related, and burnout. **Results**: Participants varied in the demographic characteristics suggesting we identified a diverse population of respondents. Overall, work-related and work/family issues that contribute to retention were neutral with the exception of irregular hours (mean=3.7±1.3) and salary (mean=3.9±1.4). In addition, male and female respondents indicated relatively neutral perceptions on burnout factors. Burnout factors contributed to retaining women more than men regarding hopelessness ($H=7.201$, d.f.=1, $p=0.007$), loss of idealism ($H=4.757$, d.f.=1, $p=0.029$), detachment to others ($H=4.179$, d.f.=1, $p=0.041$), and pessimistic thinking ($H=4.800$, d.f.=1, $p=0.028$). Those in relationships and with children also experienced work/family and burnout factors comparatively, including added responsibility at home ($H=26.235$, d.f.=3, $p<0.001$), children/parenting responsibilities ($H=26.235$, d.f.=3, $p<0.001$), feeling down in the dumps ($H=7.909$, d.f.=3, $p=0.048$), difficulty concentrating ($H=8.093$, d.f.=3, $p=0.044$), feelings of depression ($H=9.112$, d.f.=3, $p=0.028$), and feelings of frustration ($H=8.405$, d.f.=3, $p=0.038$). **Conclusion(s)**: Symptoms of burnout and life stressors contribute to the lack of retention in the profession more in females, yet previously theorized attributes such as staffing issues, demanding schedule, role ambiguity, role strain and lack of flexibility do not appear to be factors. Life-work issues such as salary and irregular work hours were greater factors in retention than previously noted in the literature. Women appear to be more affected by and work/family issues contributing to retention.

Factors And Strategies That Contribute To Work Life Balance Of Female Athletic Trainers Employed In The NCAA Division I Setting

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Context: Work life balance (WLB) can be challenging particularly for female athletic trainers (FATs). Evidence suggests FATs persist in the profession because of job enjoyment, increased autonomy, and social support networks. Departure factors such as long hours, travel, and inflexibility of schedules often comprise issues with WLB. Time management, support networks, and setting boundaries are strategies used to find WLB, however, little is known about the strategies FATs use to maintain WLB in the Division I setting as they seem to struggle more with finding WLB potentially due to the responsibilities associated with motherhood. **Objective:** To gain insight of contributing factors and strategies used by FATs employed in the Division I collegiate setting to fulfill WLB. **Design:** Structured, online asynchronous interviews via QuestionPro™ **Setting:** NCAA Division I Collegiate setting. **Patients or Other Participants:** 27 FATs (single=14; married=6; married with children=7) currently employed as full-time ATs in the NCAA Division I setting participated. Majority of FATs were contracted for 12 months and worked 58±19 hours a week. Primary sport coverage responsibility was women's basketball (9 FATs) followed by women's soccer (7 FATs) and football and volleyball (3 FATs). **Data Collection and Analysis:** FATs responded to a series of open-ended questions via reflective journaling using QuestionPro™, a secure data tracking website. The survey was

piloted prior to distribution. Data was examined borrowing from the principles of general inductive approach. Trustworthiness was established by multiple analyst triangulation, member interpretive review, and peer review. **Results:** Regardless of marital status, participants indicated 3 main factors influencing WLB; hours worked and travel, inflexibility and control of work schedules, and salary. These factors have been shown to affect retention by pressuring ATs to sacrifice time spent with family and limiting personal time, while insufficiently meeting their financial needs. FATs who were married and/or had children found the ability to prioritize and have separation from work as useful strategies to fulfill WLB. Single FATs utilized time away through exercise as a means to achieve WLB. Regardless of marital status, the main factor necessary to accomplish WLB was to have a strong support system both at work and home. No formal policies or strategies were in place to help mothers achieve a work life balance. **Conclusions:** As indicated in previous research, FATs experience issues with WLB in the Division I setting. FATs should continue to make time away from the role of athletic trainer and as the literature indicates, capitalize on informal resources such as co-worker support as a means to maintain WLB. WLB strategies are useful, but formal policies need to be established to help retain FATs in the profession. Future research may investigate what policies and strategies can be employed to achieve WLB.

The Professional Socialization Of Athletic Trainers In The Professional Sport Context

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Context: The professional socialization process consists of recruitment, anticipatory socialization, organizational socialization, and role continuance. To date, the professional socialization of athletic trainers (ATs) in high school, college, and clinical/rehabilitation settings has been investigated, but a lack of information pertaining to professional socialization of ATs in the professional sport context has been neglected. **Objective**: To gain insight and understanding of the anticipatory and organizational socialization experiences of ATs working in the professional sport settings with an emphasis on identifying aspects of gaining entry into the professional setting and those experiences that best prepare individuals for work in the professional context. **Design**: Qualitative study using one-on-one phone interviews. **Setting**: Professional sport. **Patients or Other Participants**: 12 males aged (M ± SD) 47 ± 8 with 23 ± 9 years of experiences were recruited from professional teams in baseball, basketball, football, and hockey via purposive sampling as well as snowball sampling. **Data Collection and Analysis**: In-depth, one-on-one interviews were conducted. The interviews were digitally recorded and transcribed verbatim. Textual data was analyzed using inductive content analysis. Trustworthiness was established with multiple analyst triangulation and peer debriefing. **Results**: Four themes emerged from the inductive analysis: 1) High Level of Professional Challenge During Anticipatory Socialization Period—participants were challenged by mentors and instructors early in educational experiences to set themselves apart from others; 2) Initial Preparatory Experiences—volunteer activities with the teams, working sanctioned off season developmental league competitions, camps, or engaging in internships were necessary to network with professional team athletic trainers and gain entry into the work setting; 3) Sacrifice—participants expressed financial and family time sacrifices in order to work in the professional setting; and 4) Learning through Networking—professional team societies represent a strong brotherhood or fraternity whereby the participants could rely on others for advice and information related to the nature of the roles in the profession along with emotional support and educational experiences. **Conclusions**: Being challenged to excel and take the initiative to engage in preparatory experiences such as voluntary or low-pay internships, camps, and team sponsored activities appears necessary to network with professional ATs and gain entry into the professional sport setting. Once inducted into the sport context, personal sacrifice is essentially a constant throughout the AT's career in professional sports. High level financial reward may require moving from an assistant's position into a head AT position or by being promoted from minor leagues to the major league level. The professional sport setting emphasizes the learning of the role through personal interactions via a network of professional society members who offer social support and educational opportunities to one another to facilitate the socialization and advancement of its members. This project was funded by the National Basketball Athletic Trainers' Association Foundation

Supervising Athletic Trainers' Perspectives On Professional Socialization Of Graduate Assistant Athletic Trainers In The Collegiate Setting

Thrasher AB, Walker SE, Hankemeier DA, Pitney WA: Ball State University, Muncie, IN, and Northern Illinois University, DeKalb, IL

Context: Many newly credentialed athletic trainers gain initial work experience as Graduate Assistants (GA) in the college setting, yet it is unknown how they are socialized into their roles. Exploring the perceptions of GA supervisors in the collegiate setting as to how GAs are socialized could provide insight into how this process occurs. **Objective**: To explore how GAs are socialized in the collegiate setting. **Design**: Consensual Qualitative Research (CQR) **Setting**: Individual phone interviews **Patients or Other Participants**: 21 collegiate ATs who had supervised GAs in the collegiate setting for a minimum of eight years participated in this study (16 male, 5 female; years of supervision experience: 14.6±6.6). Participants who met the inclusion criteria were recruited via an email from the Board of Certification database. Interviews were conducted until data saturation occurred. **Data Collection and Analysis**: Data were collected via phone interviews which were recorded and transcribed verbatim. Data were analyzed via a four-person consensus team who independently coded the data and compared ideas until a consensus was reached and a codebook was created. An independent auditor analyzed the domains and core ideas to ensure reliability. Trustworthiness was established through member checks and multi-analyst triangulation, which is the nature of consensual qualitative research. **Results**: Five themes emerged: 1) GA Role expectations, 2) Previous preparation, 3) GA Role Orientation, 4) Program's role in supporting and developing GAs, and 5) Shortcomings and success. Supervisors expected the GAs to provide coverage for their respective sport at the level of a new clinician; however, supervisors often expected the GAs to function autonomously as experienced full-time ATs. The majority of the supervisors believed that GAs were adequately prepared to deliver patient care but lacked the confidence and skills to communicate effectively with coaches, parents, and physicians regarding patient care. Supervisors perceived GAs lack the ability to fully execute their various roles (e.g., progress patients through rehabilitation), which was often due to a lack of hands-on experience. GAs were oriented to their roles and expectations both formally (e.g., orientation/weekly meetings) and informally (e.g., mentorship when initiated by GA or immediate role immersion). Supervisors believed personal characteristics of the individual GA (e.g., arrogance) inhibited their effectiveness in their role more so than their professional preparation. Supervisors report intervening or mentoring as a way to professionally develop the GAs and address their shortcomings. Supervisors felt most GAs adapt to their role over time (e.g., from 1 to 6 months) and are successful at meeting expectations. **Conclusion**: Supervisors believed graduate assistantships are important in the professional growth of new ATs to help transition them into clinical practice. Supervisors are responsible for professionally developing GAs, but several supervisors have unrealistic expectations for GAs to practice as experienced ATs.

Free Communications, Oral Presentations: Neuromuscular Characteristics of Dance and Warrior Populations

Tuesday, June 25, 2013, 8:00AM-9:00AM, Palm C; Moderator: Jatin Ambegaonkar, PhD, ATC, OT

Neck Strength, Flexibility, Posture, And Proprioception Differences Between Healthy Male And Female Soldiers In The US 101st Airborne Division (Air Assault)

McFate DA, Nagai T, Abt JP, Sell TC, Smalley BW, Wirt MD, Lephart SM: Neuromuscular Research Laboratory, Department of Sports Medicine and Nutrition, School of Health and Rehabilitation Sciences, University of Pittsburgh, Pittsburgh, PA; US Army School of Aviation Medicine, Fort Rucker, AL; Blanchfield Army Community Hospital, Fort Campbell, KY

Context: Neck pain is a common complaint of military personnel, especially in female populations. Researchers have identified several musculoskeletal and neuromuscular characteristics that may predispose individuals to neck pain such as decreased muscular strength. In many cases female Soldiers are assigned to the same military occupational specialties (MOS) as male Soldiers and are required to perform identical duties under similar physical demands. This combination may ultimately place females at greater risk of musculoskeletal injuries including neck pain. **Objective:** To determine if neck strength, flexibility, posture, and proprioception differences existed between healthy male and female Soldiers. **Design:** Cross-sectional study. **Setting:** Research laboratory. **Participants:** A total of 12 female (Age=29.8±4.7 years, height=164.5±9.2 cm, weight=68.7±3.6 kg) and 12 male Soldiers (Age=29.2±3.9 years, height=175.2±5.6 cm., weight= 82.1±9.8 kg) were recruited. Subjects were matched based on age (±3 years) and MOS. All subjects were free of musculoskeletal injuries preventing active duty. **Interventions:** All subjects underwent the following assessments: cervical strength, shoulder strength, cervical flexibility, forward head and shoulder posture, pectoralis minor length, and cervical proprioception. Strength was measured using hand-held dynamometry with the exception of shoulder elevation, which was tested using an isokinetic dynamometer. Flexibility was measured using a cervical range of motion instrument, and posture was measured using a carpenters' double-square device. Proprioception was determined using a 3D motion capture system. All tests were performed bilaterally when possible. Paired *t*-tests were used to compare genders with significance set at $p < 0.05$ *a priori*. **Main Outcome Measures:** The dependent variables were peak force (normalized to body mass) for neck flexion, extension, lateral flexion, rotation, and shoulder abduction/ elevation, cervical range of motion (ROM) for flexion, extension, lateral flexion, and rotation, forward head (FH), right/left shoulder posture (RSP, LSP), pectoralis minor length, and cervical active joint position sense. **Results:** Female Soldiers demonstrated significantly less strength across all measurements ($p<0.05$). Female Soldiers also demonstrated significant increases in cervical rotation ROM (F: 80.5±6.2°, M: 74.3±4.8°, $p=0.013$) and significant decreases in FH (F:20.5±1.5 cm, M:22.2±1.4 cm, $p=0.015$), RSP (F:14.4±2.7 cm, M:17.1±2.7cm, $p=0.009$), LSP (F:13.7±2.3 cm, M:15.6±2.3 cm, $p=0.026$). **Conclusions:** The current results indicate gender-related differences in various musculoskeletal characteristics. Female Soldiers displayed better flexibility and posture and similar proprioception compared to male Soldiers, but they had significantly less strength which may predispose them to injury. Females typically have a smaller body size than males, which would indicate a need for increased muscular strength relative to body mass in order to safely and properly perform the occupational tasks required of them. Decreased muscular strength also influences joint stability, which may contribute to increased injury risk. Further research should focus on identifying modifiable risk factors for neck pain and developing interventions influencing those characteristics. Supported by USAMRMC #W81XWH-11-2-0097

Effect Of A Lower Extremity Injury Prevention Program On Physical Performance Scores In Military Recruits

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Context: The implementation of injury prevention programs in athletics has become more common due to emerging evidence supporting their efficacy. Many of these programs are designed to improve movement patterns associated with lower extremity injury; however, the impact of these programs on general physical performance has not been evaluated. **Objective:** The purpose of this study was to compare physical performance scores between subjects who participated in a lower extremity injury prevention program during warm-up and those who performed a standard warm-up. **Design:** Cluster randomized controlled trial. **Setting:** US Service Academy. **Participants:** 1068 college freshmen entering the academy in June 2011. **Interventions:** Groups performed one of two 10-minute warm-ups 2-3 times per week for six weeks. The intervention group performed the Dynamic Integrated Movement Enhancement (DIME) warm-up consisting of 10 exercises designed to improve lower extremity alignment, decrease ground reaction forces during landing, and increase lower extremity balance and core strength. The control group performed the Army Preparation Drill consisting of 10 exercises designed to prepare soldiers for physical training exercises. Both groups completed the same num<text>ber of sessions. At the end of basic training, all subjects completed the Army Physical Fitness Test (APFT) which includes a timed 2-mile run and 2 minutes each of push-ups and sit-ups. **Main Outcome Measures:** The main outcome measures were raw and scaled scores for the three APFT events as well as the total APFT score. Initially, independent t-tests were used to assess between group differences for each dependent variable. Important variables were carried forward into multivariable logistic regression models to control for the influence of confounding variables such as gender and BMI. **Results:** Subjects in the intervention group completed the 2-mile run 20 (95%CI: 9.27, 31.14) seconds faster when compared to the control group ($p<.001$). On average, subjects in the DIME group completed the run in 808(±79) seconds compared to the control group who completed the run in 828(±102) seconds. This corresponded with significantly higher scaled scores for the 2-mile run in the DIME group ($p<0.001$). There were no significant differences in push-up or sit-up scores between the groups; however, significantly higher total APFT scores were observed in the DIME group (275±32) when compared to the control group (269±34) ($p<.001$). Similar results were observed in multivariable models after controlling for gender and BMI. **Conclusions:** Injury prevention programs have become increasingly popular based on preliminary research supporting their efficacy. However, because many of these programs are time-consuming they are not always well-received by coaches. Our findings suggest that the DIME group had better cardiovascular fitness and overall fitness scores when compared to the control group after a six-week lower extremity injury prevention intervention. Whether the DIME program influences skill-related fitness remains unclear.

Female Dancers Stabilize Earlier Than Recreationally Active Females Following A Jump Landing Task

Pye ML, Ross SE, Schmitz RJ, Shultz SJ: University of North Carolina at Greensboro, Greensboro, NC

Context: Poor balance has been associated with increased anterior cruciate ligament (ACL) injury risk. Dancers are more stable than athletes during single leg static stance, which may in part explain dancer's decreased incidence of ACL injury. However, the functional implications of static balance measures have been questioned given the dynamic nature of sport. Whether dancers are also more stable during a dynamic balance task than athletes has not been investigated. **Objective:** To compare dynamic balance in collegiate dancers and recreationally active individuals. **Design:** Descriptive cohort study. **Setting:** Laboratory setting. **Patients or Other Participants:** Six female dancers (DA) [19.8 ± 1.2 yrs, 161.7 ± 5.2 cm, 58.0 ± 8.6 kg] and 6 recreationally active females (RA) [22.2 ± 1.6 yrs, 162.3 ± 8.0 cm, 63.0 ± 5.6 kg]) with jumping experience. All participants were healthy and participated in a minimum 30 minutes of physical activity 3 times a week. Dancers were also required to have at least 5 years of contemporary or ballet training. **Intervention:** Participants performed 3 trials of a jump stabilization task. This consisted of a forward jump that was standardized to a distance of 40% the participant's height. Subjects jumped over a 25 cm barrier and landed on a single limb on a force plate. They were then required to hold the single limb stance for 10 s. Both dominant (stance limb) and non-dominant limbs were tested in shoe and barefoot conditions. All trials were counterbalanced. Ground reaction force data were acquired (1000Hz) over 10 s. **Main Outcome**

Measures: Time to Stabilization (TTS) (s) was defined as the point at which an unbound third order polynomial fit to the ground reaction force reached values of the ground reaction force of a stable single limb stance. TTS was computed for anterior-posterior (AP) and medial-lateral (ML) directions. Differences between DA and RA were assessed using independent t-tests ($P<0.05$) and calculating effect sizes. **Results:** Dancers stabilized sooner in the AP direction on the dominant limb in the shoe condition (DA= 2.55± 0.7 s; RA= 3.85 ± 0.9 s; P =0.02). No other significant differences were noted. However, a large effect size (*Cohen's d=0.76*) was observed in the AP direction on the dominant limb during the barefoot condition with dancers again stabilizing sooner (DA= 2.83 ± 0.8 s; RA= 3.40 ± 0.7 s; *P =0.21).* **Conclusions:** The TTS measure is sensitive for detecting dynamic balance differences between healthy dancers and recreationally active females. Dancers require less time to stabilize compared to recreationally active individuals on the dominant limb in the AP direction. Future research may explore the relationship between dancers' ability to stabilize quickly following a jump landing task and their low incidence of ACL injury.

Coordination Variability Is Higher In Non-Dancers Than In Dancers During A Jumping Task

Jarvis DN, Armour Smith J, Kulig K: University of Southern California, Los Angeles, CA

Context: Movements are often studied through biomechanical analysis of individual joints or segments, but the study of coordination patterns across multiple segments provides a more in-depth approach to the examination of skilled athletic movements. In addition, movement variability across repeated trials is related to athletic skill and plays an important role in sports performance. Characterization of coordination patterns and variability in persons of varying athletic skill will indicate qualities associated with elite task performance. **Objective:** To examine trunk and lower extremity (LE) kinematics and coordination variability in dancers and non-dancers during rate-controlled sautés (bipedal vertical dance jumps). **Design:** Cross-sectional. **Setting:** Biomechanics research laboratory. **Participants:** Twenty healthy females; ten (age=24.8± 2.2 years; weight=57.7 ±7.1 kg; height=1.63 ±0.07 m) with no prior formal dance training, and ten (age=27.1 ±3.5 years; weight=58.4 ±5.9 kg; height=1.65 ±0.07 m) professional dancers with an average 20.8±5.3 years of dance training. **Interventions:** A three-dimensional motion analysis system was used to collect kinematic data. Participants performed 20 consecutive sautés at a controlled rate of 95 beats per minute. Sagittal plane kinematics of the middle 10 consecutive jumps for each participant were calculated. **Main Outcome Measures:** Kinematic variability was assessed using the mean standard deviation of angular displacement for individual joints or trunk segments. The vector coding method was used to quantify coordination variability between the knee and ankle, hip and knee, and thoracic and lumbar segments. The mean coupling angle across the 10 trials was calculated for each participant using circular statistics, and the angular deviation of the coupling angle was used to assess coordination variability. Overall trunk and LE variability trends between groups were examined using independent t-tests ($p<0.05$). **Results:** Kinematic profiles were similar between the two groups, indicating that both groups were successful in performing the jumping task. Kinematic variability was higher for non-dancers (3.2±1.8°) than for dancers (2.3±1.6°) in the LE joints ($p<0.01$), but there was no difference between groups for the trunk ($p=0.16$). However, the difference in LE variability between groups was only 0.9°, which is smaller than the standard error of measure for the three lower extremity joints (SEM ankle=0.9°, knee=2.1°, hip=3.3°). When looking at coordination variability between joints, non-dancers had higher variability (38.0±8.9° trunk; 21.5 ±16.8° LE) than dancers (31.8±8.5° trunk; 16.4±15.6° LE) for both lower extremity ($p<0.001$) and trunk ($p=0.009$) couplings. **Conclusions:** Trained dancers demonstrate similar kinematics but lower coordination variability compared to non-dancers during a simple jumping task. Examination of coordination between joints may allow for a more thorough understanding of skilled athletic movements than kinematic analysis alone.

Secondary School Athletic Trainers' Referral Patterns For Patients Following Sport-Related Concussion

McCarty CW, Mayfield RM, Parsons JT, Valovich McLeod TC: A.T. Still University, Mesa, AZ

Context: As state concussion laws continue to evolve, it is important to understand the factors that influence athletic trainers' (AT) decisions to refer patients following sport-related concussion. It is also valuable to determine whether ATs' have established interprofessional relationships to ensure the proper management of patients following sport-related concussion. However, it is unclear whether ATs in the secondary school setting have direct access to other healthcare professionals. **Objective:** To determine secondary school ATs' referral patterns for adolescent athletes following sport-related concussion. **Design:** Cross-sectional survey design. **Setting:** Self-reported online survey. **Patients or Other Participants:** 851 clinicians (25.9% response rate) from a convenience sample of ATs practicing in the secondary school setting (308 males, 376 females, 167 missing, age=37.28±10.13). **Interventions**: Participants were solicited via email to complete the *Athletic Trainers' Beliefs, Attitudes, and Knowledge of Pediatric Athletes with Concussions (BAKPAC-AT)* survey. The BAKPAC-AT consisted of several multipart questions to assess ATs' current practices regarding referrals following sport-related concussion and established relationships with other healthcare professionals. **Main Outcome Measures:** The dependent variables were participants' responses to the referral and established relationship questions. Descriptive statistics were reported to describe overall practices. Separate forward stepwise binary logistic regression analyses ($p<.05$) were used to determine whether any personal (years certified, experience in secondary school setting) or school (enrollment, type, presence of football) factors predicted ATs' decisions to refer patients to physicians following sport-related concussion. **Results:** A majority of ATs (77.8%, n=662) refer adolescent athletes to a physician following sport-related concussion. Nearly half of these respondents (48.8%, n=415) indicated they refer 100% of concussion cases per year. The most influential factors that lead to a referral were state law (40.3%, n=343), personal preference (34.7%, n=295), and school district policy (24.8%, n=211). The regression analyses revealed no significant personal or school predictors regarding ATs' referral decisions to physicians. ATs most commonly reported having an established relationship with sports-medicine fellowship physicians (80%, n=596), neurologists (33%, n=243), neuropsychologists (27%, n=201) and physician assistants (27%, n=197), while 7% of respondents (n=52) do not have established relationships with other healthcare providers. ATs "always" (18%, n=106) and "almost always" (37%, n=220) referred patients to a sports medicine physician, yet despite having established relationships, "rarely" referred to neurologists (39%, n=93) and neuropsychologists (36%, n=72), and "never" referred to physician assistants (37%, n=73). **Conclusions:** Most ATs refer patients to physicians following sport-related concussion, and occasionally refer to other healthcare professionals. While state regulation and personal preference were primary factors influencing referral decisions, it is unclear at what point of care the referral occurs. Because effective referral can impact the outcome of a case, future research should assess when referral decisions occur and what factors lead ATs to refer to healthcare professionals other than physicians.

Concussion Occurrence And Perception Survey For Athletes (COPSA)

McDevitt J, Tierney RT, Bright N, Komaroff E: Temple University, Philadelphia, PA

Context: Underreporting of concussions is a problem in high school athletics. Additionally, little is known as to what factors influence the athletes' unwillingness to report concussive signs and symptoms (s/s). **Objective:** Identify athletes' perception, reporting values, and occurrence of concussive s/s. **Design**: Survey study. **Setting**: Urban high schools. **Participants**: 302 male and female athletes participating in a 2010-2011 sport. Response rate was 20.13%. **Interventions:** A construct validation process was used to design a paper and pencil survey. Flesch-Kincaid program was utilized to ensure appropriate wording. A panel of survey-research design and concussion experts evaluated the survey's content validity. Athletes were grouped into high head impact sport (HHIS), low head impact sport (LHIS), or both (B). Frequency statistics and chi-squares were used to analyze data. Three (group) x three (response) chi-square analyses were used to test associations in response options between groups (p = .05). Significant chi-squares were followed up with pair wise 2 x 3 chi-squares using a Bonferroni correction (p = .017) as needed. **Main Outcome Measure(s):** Athletes responded to demographic information and concussion s/s data across 4 domains (knowledge, concern, report, and occurrence). Athletes answered yes or no questions as well as questions using a 5-point likert scale. **Results**: Over half of LHIS athletes and 20% of HHIS athletes reported they did not have any concussion knowledge (p =.002). Seventy-two percent of LHIS athletes were "maybe concerned" about poor balance (p = .001), and over half of HHIS athletes "would not even think about being concerned" about poor balance (p= .007). Least concerning s/s were extra sad (42%), noise hurts my head (34%), nervous (33%), and easily tired (30%). Seventy-one percent of the LHIS athletes and 50% of HHIS athletes reported they "may report" feeling easily fatigued (p =.014). Signs and symptoms least likely to be reported were grumpy (36%), nervous (30%), and extra sad (27%). Almost 30% of HHIS athletes stated they "sometimes" get dizzy after a sports-related head impact (p = .003). Sixty-three percent of athletes participating in B reported "sometimes" feeling dizzy after a sports-related head impact (p = .003). The most commonly occurring s/s that "sometimes" or "always" occur after a head impact were headache (40%, 9%), dizzy (29%, 5%), blurred vision (24%, 3%), and "dinged" (19%, 4%). **Conclusion**: Urban high school athletes are concerned and would report s/s that are overtly detrimental to their health, but those s/s that occur most often after a head impact athletes seem to be less concerned about and may not report those s/s. Athletic trainers should be aware of the s/s that are occurring most often and that students are less likely to be concerned or report.

Preliminary Analysis Of Concussion Occurrence And Perception Among Collegiate Athletes

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Context: Each year concussions account for an estimated 300,000 to 3.8 million injuries in the United States. However, due to suspected underreporting of concussions, these are likely underestimates as many athletes may be unaware of the mechanisms and/or signs and symptoms (s/s) of said injury. **Objective:** To elucidate collegiate athletes' knowledge, concern, reporting habits, and occurrence of concussive s/s using the Concussion Occurrence and Perception Survey for Athletes (COPSA). **Design:** The COPSA is an anonymous, cross-sectional, paper-and-pencil survey. **Setting:** Two- and four-year urban colleges. **Patients or Other Participants:** A volunteer sample of collegiate athletes completed the survey; of the 100 surveys distributed, 88 were returned (88% response rate). The forty-nine male (60.5%) and 32 female (seven unanswered) athletes surveyed ranged in age from 18 to 30 years with primary participation in over 14 sports (e.g., base/softball, boxing, football, rugby, swimming, track). Athletes reported an average 12.56 ± 5.08, 4.79 ± 2.69, 2.75 ± 1.41, and 1.73 ± 0.88 years of participation in their primary (n = 75), secondary (n = 34), tertiary (n = 20), and quaternary (n = 13) sport, respectively and primarily played gymnastics (48.8%), soccer (17.5%), and base/softball (15%). **Interventions:** The COPSA was created using a construct-validation process and underwent content validity using a panel of survey-research and concussion experts. Athletes were

recruited via a researcher-initiated team meeting and those willing to participate completed the survey and submitted them to a designated box. Athletes were defined as those currently participating on a sports team at their institution. **Main Outcome Measures:** Concussive knowledge, concern, reporting habits and occurrence by indicating: "yes" or "no" to 3 questions: "I know about sports-related head injuries and concussions, "Sports-related head injuries are a problem in the sport(s) I play," and "There are things I can do to prevent/minimize sports-related head injuries"; "not", "maybe", or "very concerned"; "definitely not", "maybe", or "definitely tell"; "never", "sometimes", or "always experience" regarding 19 concussive s/s post-impact, respectively. Data were analyzed via frequency distributions. **Results:** Athletes were most concerned with and more likely to report overt signs of concussion (e.g. loss of consciousness, 81% and vomiting, 69%). However, those with a history of concussion (n=25) frequently stated these overt signs never occurred (60%, 63%, respectively). Overall, athletes claimed to know some (64.8%) to quite a lot (31.8%) about concussions, but responded that they "might be" concerned or report a majority (15/19) of their concussive s/s. **Conclusions:** Possible confusion and suspected underreporting of concussions warrant increased education initiatives. Sports-medicine professionals should capitalize on the notion that most collegiate athletes believe there are things they can do to prevent/minimize the injury and properly educate athletes regarding its s/s and highly individualistic presentation.

Secondary School Athletic Trainers' Knowledge And Perceptions Of Academic Accommodations Following Sport-Related Concussion

Mayfield RM, McCarty CW, Parsons JT, Valovich McLeod TC: A.T. Still University, Mesa, AZ

Context: Sport-related concussions not only affect sport participation, but can also hinder academic success. There has been recent emphasis on cognitive rest and appropriately managing return-to-learn as part of a comprehensive concussion program. Following a sport-related concussion, student-athletes may benefit from academic accommodations (AA) in the classroom; however athletic trainers' (AT) knowledge and use of AA is unknown. **Objective:** To determine secondary school ATs' knowledge and perceptions of 504 plans, individualized education programs (IEP), and ATs' role in AA. **Design:** Cross-sectional design. **Setting**: Self-reported online survey. **Patients or Other Participants**: 851 clinicians (25.9% response rate) from a convenience sample of ATs that were currently practicing in the secondary school setting (308 males, 376 females, 167 missing, age= 37.28±10.13). **Interventions:** Participants were solicited via email to complete the *Athletic Trainers' Beliefs, Attitudes, and Knowledge of Pediatric Athletes with Concussions (BAKPAC-AT)* survey. The BAKPAC-AT consisted of several multipart questions to assess ATs' knowledge and perceptions regarding 504 plans, IEPs, and ATs role in returning student-athletes back into the classroom. Independent variables included employment status (full-time vs. part-time), employment model (direct vs. outreach), years certified, and years of experience in the secondary school setting. **Main Outcome Measures:** The dependent variables were participants' responses to the AA questions. Spearman correlations were used to assess relationships and Mann Whitney U and Chi Square tests ($p<.05$) were used to identify differences. **Results**: Respondents reported 44±0.33% of sport-related concussions managed received AA. Respondents employed directly by the school were more knowledgeable of 504 plans ($p<.001$), IEP ($p<.001$), and had a greater belief that AT's should have a role in AA. There were no significant differences between employment status and knowledge of 504 plans (p=.143), IEP (p=.856), or perceptions of AT's role in AA (p=.219). There was a significant positive correlation between the numbers of years certified and knowledge regarding 504 plans ($r=.343$, $p<.001$) and IEP ($r=.328$, $p<.001$). A significant relationship was also found between years of experience at the secondary school and 504 plan knowledge ($r=.347$ $p<.001$), and IEP knowledge ($r=.327$, $p<.001$). There were no significant associations between years certified ($r=.057$, $p=.138$) or years of secondary school experience ($r=.001$, $p=.970$) regarding perceptions of ATs' role in AA. **Conclusions:** ATs employed directly by the secondary school and those with more experience as a secondary school AT were more knowledgeable of AA. This may be the result of knowledge gained as a member of the school staff. Understanding AA is important for all ATs, as the prescription of cognitive rest and return-to-learn is becoming more widely recommended in concussion management. Further research should be conducted gathering prospective information of AA for student-athletes following sport-related concussion as well as educating ATs on the importance of addressing academics following concussion.

Free Communications, Oral Presentations: Various Approaches for Classroom and Clinical Education

Tuesday, June 25, 2013, 10:30AM-11:45PM; Palm C; Moderator: Jolene Henning, EdD, ATC, LAT

The Entry-Level Masters Route To Certification: Program Standards, Outcomes And Student Characteristics

Ostrowski JL: Weber State University, Ogden, UT

Context: Entry-Level Masters athletic training education programs (ELM ATEPs) have increased by over 400% in the past 10 years, however little is known about characteristics of students who enroll or about the standards of programs themselves. **Objective:** Explore characteristics of ELM athletic training students (MATS) to develop a profile; explore ATEP requirements, retention and BOC pass rates, and placement rates. **Design:** Cross-sectional survey design. **Setting:** Online survey. **Patients or Other Participants:** All ELM Program Directors (PDs) listed on the CAATE website as of April 2012 were contacted. PDs were asked to complete a survey and to forward a survey link to MATS currently enrolled in their ATEP. 79 MATS (136 surveys forwarded; 58% response rate) and 11 PDs (25 PDs contacted; 44% response rate) completed the surveys. MATS: average age 24.7 years (range: 21-42); 68% female, 56% first-year MATS. Average years experience as PD: 8 (SD: 3.6; range: 3-12). **Interventions:** Surveys administered online via Formstack.com. Survey responses were returned to the server as anonymous data. **Main Outcome Measures:** MATS survey: demographics (age, race, standing in ATEP), characteristics of undergraduate education, rationale for enrolling in ELM program, perceived level of preparation to become a certified AT. PD survey: demographics (number of years as PD, PD's route to certification), history of ATEP, retention/graduation/BOC pass rates, graduation requirements, perceived preparation of MATS to practice as ATs. Descriptive statistics and non-parametric correlations were calculated. **Results:** MATS survey: profile of MATS is a student in their mid-20s, Caucasian, received Bachelor Degree in exercise science < 2 years prior to entering an ELM program. Geographical area and institution's reputation were primary contributing factors in choosing an ELM program. Following graduation 93.5% planned to seek employment using ATC credential. No significant DV correlations. PD survey: 91% first-to-second year average retention rate; 81% average two-year graduation rate. Average first-time BOC pass rate reported was 91.7% (three-year aggregate). 91% of ELM ATEPs require a thesis or structured research project. The lowest BOC pass rates were reported in ATEPs without structured research requirements (r=0.762, p=0.006). Significant correlation between retention rates and graduation rates (r=0.696, p=0.025). **Conclusions:** Despite speculation regarding the future of athletic training education, little is known about the ELM route to certification. A profile of MATS will aid in ATEP recruitment efforts. Our data indicates that the overwhelming majority of ELM graduates will practice professionally using their ATC credential (93.5% MATS report, 93.6% PD report). First-time BOC pass rates reported in ELM ATEPs are well above the national average. The ELM route to certification appears to produce high-quality athletic trainers who are likely to remain in the field. Institutions considering developing an ELM program should strongly consider incorporating a thesis or structured research project.

Employers' Knowledge Levels Of The Various Types Of Athletic Training Education Programs

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Context: As athletic training education continues to evolve, it is essential that employers have an understanding of the differences between the types of athletic training education programs (ATEPs) so they can make the best hiring decisions. **Objective:** To assess athletic training employers' perceived knowledge (PKn), objective knowledge (ObjK), and their confidence in their knowledge (CfK) of the types of ATEPs available within athletic training. **Design:** Cross-sectional survey. **Setting:** Web-based survey. **Patients or Other Participants:** 133 of 420 employers (31.67% response rate) from a convenience sample of employers from the NATA public vacancy notice (79 males, 54 females, age=42.89±9.84) participated in the study. Participants were separated by job type, which included 65 clinicians, 42 educators, and 26 administrators. **Interventions:** Participants were solicited via email (between Fall 2010 and Spring 2012) to complete the online survey. The PKn section included four Likert-scale items (range 1-4) regarding how knowledgeable participants perceived themselves regarding professional ATEPs, professional master's ATEPs, and post-professional ATEPs. The ObjK and CfK sections included 12 multiple-choice questions (MCQ) about the different ATEPs accompanied by a Likert-scale item (range 1-4) assessing their CfK for each MCQ. Reliability from an unrelated pilot sample (n=13) for the

OKn section was determined to be excellent; percent agreement averaged 96% with a range of 83.33%-100%. **Main Outcome Measures:** The independent variable was employer job type (educator, clinician, administrator) and dependent variables were PKn, ObjK, and CfK composite scores. ObjK scores were calculated by awarding one point for each question answered correctly (maximum score=12). PKn and CfK scores were attained by totaling all values and calculating the average value back to the Likert scale (total divided by 4). Higher scores indicated higher perceived knowledge or a higher confidence in their knowledge. Significant differences ($P<.05$) were calculated using one-way ANOVAs and Kruskal-Wallis H tests. **Results:** Overall, participants perceived themselves "moderately knowledge-able" (3.11/4.0±0.73) of ATEPs, however composite ObjK scores were 7.27±2.86 (CI=6.78-7.76). Despite mediocre composite ObjK scores, employers were "moderately confident" (3.04/4.0±0.68) in their ObjK responses. Job type was associated with higher PKn scores ($H(2)=20.36, P<0.001$), ObjK scores ($F=19.26, P<0.001$), and ConK scores ($H(2)=29.99, P<0.001$). Educators had higher PKn scores (3.51/4.0±0.50), ObjK scores (9.26±2.26,CI=8.55-9.97), and CfK scores (3.48/4.0±0.50) than clinicians (PKn=3.01/4.0±0.67, ObjK=6.48±2.56,CI=5.84-7.11, CfK=2.84/4.0±0.52) and administrators (PKn=2.72/4.0±0.90, ObjK= 6.04 ±2.82,CI=4.90-7.18, CfK=2.81/4.0±0.91), indicating that they were more knowledgeable and more confident of the differences between ATEPs than the other two groups. **Conclusions:** Findings from this study suggest that employers are only moderately familiar with differences between ATEPs. With only limited knowledge of the qualifications attained from each type of ATEP, employers may have difficulty selecting the best candidate for employment. As educational programming continues to change, it is essential to educate employers about qualifications from differing programs.

The Relationships Among Workload, Instructor Approach To Teaching, And Student Evaluation Of Teaching

Wilkinson RD: University of Wisconsin – Milwaukee, Milwaukee, WI

Context: Instructors in Commission on Accreditation of Athletic Training Education (CAATE) accredited Athletic Training Education Programs (ATEPs) have various workload assignments, including teaching, research, administration, and/or athletic training sport coverage (ATSC). Most commonly, the dual-appointment model consists of teaching and ATSC. Role strain occurs when an individual has difficulty meeting the obligations associated with multiple roles; commonly experienced by dual-appointment instructors. Various factors may impact instructor approach to teaching (IAT) and student evaluation of teaching (SET), including workload. **Objective**: The purpose of this study was to determine the relationships among workload, IAT, and SET in CAATE accredited Wisconsin ATEPs. **Design**: Self-administered surveys addressing workload, the Approaches to Teaching Inventory (ATI), and the Student Evaluation of Educational Quality (SEEQ) instrument. **Setting**: Wisconsin ATEPs. **Patients or Other Participants**: Instructors (n = 25, mean age 40.12 ± 8.293) included certified athletic trainers (AT) teaching classroom-based courses. Program directors were asked to forward recruitment materials to their AT instructors. Undergraduate students (n = 200) enrolled in courses taught by instructor participants were also surveyed. Instructors were asked to forward recruitment materials to their students. **Interventions**: Instructors completed a questionnaire addressing workload and the ATI. Each ATI question was labeled Student Focused (SF) or Teacher Focused (TF). Mean scores for SF and TF questions were

established. Students completed a questionnaire including the SEEQ, regarding their instructor. The ATI and SEEQ have demonstrated positive reliability and validity. **Main Outcome Measures**: The SEEQ includes nine sub-sets: Learning, Enthusiasm, Organization, Group Interaction, Individual Rapport, Breadth, Examinations, Assignments, and Overall. Mean scores from the overall total and the sub-sets were determined. Data were analyzed to determine statistically significant relationships ($p<.05$), utilizing the Pearson correlation coefficient. **Results**: There was a statistically significant positive relationship (.553, p=.005) between the SF mean and the total SEEQ mean. SEEQ sub-sets also demonstrated statistically significant positive relationships with the SF mean, including Enthusiasm (.582, p=.003), Group Interaction (.527, p=.008), Individual Rapport (.492, p=.015), Breadth (.421, p=.040), Assignments (.453, p=.026), and Overall (.559, p=.005). Additionally, a statistically significant positive relationship (.506, p=.010) existed between ATSC workload and the TF mean. **Conclusions**: In this study, instructors with higher SF means received higher SEEQ scores. A SF approach has been linke to improved student learning outcomes. Additionally, instructors carrying ATSC were found to approach their teaching from more of a TF approach. ATSC workload may have a negative impact on approach to teaching. Time and/or role strain may be limiting factors for exploring alternative teaching techniques for dual-appointment instructors. Further research is needed to confirm the educational impact of the dual-appointment model.

A Small Group Standardized Patient Encounter Improves Athletic Training Students' Psychosocial Intervention And Referral Skills.

Walker SE, Thrasher AB: Ball State University, Muncie, IN

Context: Athletic trainers provide social support, counseling, intervention, and referral to patients during clinical practice but report receiving little to no experience developing these skills during their education. Standardized patients (SPs) can provide this learning experience to better prepare students for clinical practice. **Objective:** The purpose of this study was to examine the effects of a small group SP encounter on athletic training students' interpersonal communication, psychosocial intervention, and referral skills (PIR). **Design**: Quasi-experimental. **Setting**: One Midwestern university. **Patients or Other Participants**: All athletic training students (N=39, 14 male, 25 female, aged 21.67±1.30) who had completed the Psychology of Injury course during the fall semester of 2006-2009 and were enrolled in a Current Concepts of Athletic Training course during the spring semester participated in this study. **Interventions**: During the fifth week of the spring semester, the experimental group (n=20; spring 2007 and spring 2009) engaged in a small group SP encounter. Randomly assigned to groups containing three or four, the participants interacted with a SP with a cocaine addiction needing PIR. Verbal feedback was provided on their performance during and after the encounter from the SP, a clinician, and instructor who were present during all small group SP encounters. The control group (n=19; spring 2008 and 2010) received no intervention. To evaluate the effectiveness of the SP encounter, all participants individually evaluated a SP with an eating disorder needing PIR ten weeks into each spring semester. Interpersonal communication and PIR were assessed by the instructor using a checklist (e.g., inquired as to perception of weight, listened, made referral). An experienced researcher/clinician in PIR reviewed the checklist to establish validity. Checklist reliability was established via inter rater reliability measures between the instructor and SP (ICC .781). **Main Outcome Measures**: The independent variable was the small group SP encounter and the dependent variable was the students' interpersonal and PIR performance measured by the checklist. An independent t-test determined the effects of the intervention on interpersonal communication and PIR skills. Data were analyzed using SPSS (Version 15.0, SPSS Inc. Chicago, IL) with an alpha level of .05. **Results**: An independent t-test revealed a significant increase in performance by the experimental group on their PIR skills (p=0.001) but no difference between the two groups on interpersonal communication skills (p=0.346). The checklist from the instructor revealed that on PIR skills, the experimental group completed an average of 4.55±1.88 out of nine skills correctly while the control group only completed 2.63±1.21 correctly. **Conclusion:** A small group SP encounter did improve students' PIR skills. These results suggest a small group SP encounter provides an efficient clinical educational experience to better prepare athletic training students for clinical practice.

An Examination of the Experiences of Athletic Training Preceptors with Different Amounts Of Clinical And Clinical Teaching Experience

Nottingham SL: Chapman University, Orange, CA

Context: The 2012 Commission on Accreditation on Athletic Training Education(CAATE) standards include several changes that allow more institutional autonomy when determining the qualifications and preparation of preceptors.Clinical Education Coordinators (CECs) must make educated decisionsregarding the selection and training of preceptors, yet minimal research exists inthis area to guide their decisions. **Objective:** To explore the experiences ofpreceptors with different amounts of clinical and clinical teaching experience toprovide information regarding the selection and preparation of preceptors.**Design:** Descriptive qualitative interview study. **Setting:** Three undergraduate CAATE-accredited Athletic Training Education Programs (ATEPs). **Participants:**17 preceptors (8 males, 9 females; 9.88 ±9.46 years of clinical experience; 5.06±3.92 years of clinical teaching experience) working in the university, communitycollege, rehabilitation clinic, and high school settings. Participants were selectedthrough a combination of purposeful and convenience sampling and had to becurrent preceptors for a CAATE-accredited ATEP. Participants were recruitedthrough the CECs of three institutions, and the researcher sought to interviewparticipants with a wide range of clinical and clinical teaching experience. Data was collected until variety of participant experiences was obtained and saturationof data occurred. **Data Collection and Analysis:** The researcher interviewed participants using an individual, in-person, semi-structured format. Interviewswere recorded, transcribed verbatim, and analyzed using the process of open,axial, and selective coding with ATLAS.ti software. Trustworthiness was established by member-checking interviews with participants and having twopeer debriefers critically review the data and researcher's findings. **Results:** Fourcategories emerged from the data, including benefits, preparation, qualifications,and challenges of being a preceptor. While participants described it wasbeneficial to have students, they also faced several challenges, includingbalancing their responsibilities as a clinician and preceptor and keeping theirknowledge current. Participants discussed that mentorship from other preceptorsand past experiences as students were primary contributors to their role as apreceptor, whereas preceptor training and communication of expectations by theCEC could have been improved to better prepare them for their preceptor role.Participants described that clinical experience, willingness to be a preceptor, andconfidence were the main qualifications for becoming a preceptor. **Conclusions:**The results of this study provide several points for CECs to consider whenselecting and preparing preceptors. CECs should ensure that potentialpreceptors are confident, established clinicians before becoming preceptors. Inaddition, CECs should ensure that they are adequately preparing andcommunicating with preceptors before and after they take on that responsibility.Lastly, educators and researchers should consider the challenges faced bypreceptors and develop strategies for managing these challenges, such ascreating efficient evaluation tools, providing easily accessible continuingeducation opportunities, and developing mentorship programs for preceptors.

Education Evidence-Based Forum

Tuesday, June 25, 2013, 12:00PM-1:00PM; Palm C; Moderators:

Effect Of Lateral Ankle Sprain On Self-Reported Disability Over A Two-Week Period

McLeod MM, Hafner R, Harkey MS, Gribble PA, Pietrosimone BG: University of Toledo, Toledo, OH

Context: Previous lateral ankle sprain (LAS) is a risk-factor for recurrent ankle sprain and development of chronic ankle instability (CAI). Increased self-reported disability is a common complaint in those with CAI. Although acute LAS patients frequently return back to physical activity within two-weeks following initial injury, limited objective investigations exist on the effect of LAS on self-reported disability and restoration of function. **Objective:** Determine differences in self-reported disability following acute LAS over time, compared to healthy controls. **Design:** Case-Control. **Setting:** Research laboratory. Patients or Other Participants: Ten LAS patients (3M, 7F, 20.80±1.75yrs, 172.21 ±11.09cm, 71.29±18.54kg) and 9 healthy controls (4M, 5F, 20.44 ±1.51yrs, 174.98±9.11cm, 75.10 ±17.05kg) participated. **Interventions:** Participants incurring a LAS during intercollegiate or recreational sports completed the Foot and Ankle Disability Index (FADI) and FADI Sport (FADI-Sp) questionnaires within 36 hours(h), and at 5, 7, 10, and 14 days(d) following the initial sprain. FADI and FADI-Sp questions are related to self-reported disability during activities of daily living, and physical activity, respectively. LAS participants underwent treatment as directed by their individual healthcare professional. **Main Outcome Measures:** FADI and FADI-Sp scores were computed as percentages, with smaller values indicating greater disability. Separate 2x5 (group by time) repeated measures analyses of variance were performed to determine differences for the FADI and FADI-Sp. Greenhouse-Geisser corrections were applied where sphericity was violated. Post-hoc dependent t-tests were performed to determine differences within groups over time. Independent t-tests were performed post-hoc to determine differences between groups at each time interval. Alpha level was set a priori at $P<0.05$. **Results:** There was a significant group by time interaction for the FADI ($F_{1.\ 2.091}=9.90$, $P<0.01$) and FADI-Sp ($F_{1.\ 1.862}=7.69$, $P<0.01$). FADI was significantly lower in LAS group compared to healthy group (100±0.00%, all time points) at 36h (72.43±12.33%, $P<0.01$), 5d (88.30±9.40%, $P<0.01$), 7d (90.06 ±9.11%, $P<0.01$), 10d (88.19 ±15.71%, $P<0.01$), and 14d (95.71±5.04%, $P<0.01$). FADI-Sp was significantly lower in LAS group compared to healthy group (100±0.00%, all time points) at 36h (55.82±25.04%, $P=0.01$), 5d (71.98 ±16.04%, $P<0.01$), 7d (80.35 ±15.83%, $P<0.01$), 10d (77.75 ±23.64%, $P<0.01$), and 14d (90.33±10.39%, $P<0.01$). FADI was significantly lower between time points 36h-5d ($P<0.01$), 36h-7d ($P<0.01$), 36h-10d ($P=0.03$), 36h-14d ($P<0.01$), 5d-14d ($P=0.02$), and 7d-14d ($P=0.03$) for LAS group. Also, FADI-Sp was significantly lower between 36h-5d ($P=0.02$), 36h-7d ($P=0.01$), 36h-14d ($P<0.01$), 5d-7d ($P=0.04$), 5d-14d ($P=0.01$), 7d-14d ($P=0.03$) for LAS group. Conclusions: Self-reported disability remained lower in the LAS group at all time - points with the greatest increases in self-reported disability between 36h-5d for FADI and FADI-Sp. For FADI, there was no significant increase between 5d-7d and 5d-10d, whereas significant increases were observed between all time points for FADI-Sp except 10d. Further studies should determine if prolonged deficits in self-reported function predict deficits in long-term joint health.

Prevalence Of Functional Ankle Instability In High School And Division I College Athletes

Tanen LM, Docherty CL, Van Der Pol BJ, Simon J, Schrader JW: Indiana University, Bloomington, IN

Context: While much research exists on the epidemiology of lateral ankle sprains, there is little information that investigates the prevalence of functional ankle instability (FAI). Ankle sprains are a common sports injury and are often regarded as trivial by athletes and coaches however, further work needs to be done to increase awareness of residual symptoms of a lateral ankle sprain including FAI. **Objective:** The purpose of this study is to determine the prevalence of FAI among high school and collegiate athletes. **Design:** Cross-sectional survey. **Setting:** Pre-participation physical examinations, pre-season parent meetings, team meetings. **Patients or Other Participants:** We collected a total of 672 questionnaires. One hundred sixty participants were excluded due to either incomplete questionnaires or a history of fractures. A total of 512 subjects remained (316 collegiate athletes [186 males, 130 females, 19.6±1.2 years] and 196 high school athletes [113 males, 83 females, 15.8±1.2 years]); response rate of 76%. **Interventions:** All athletes completed the Cumberland Ankle Instability Tool (CAIT) on both ankles. Subjects also answered a series of questions related to demographic background including: age, sex, sport, and history of lower leg fracture. For collegiate athletes, a questionnaire packet was distributed during the required pre-participation physicals. For high school athletes, parental consent was obtained prior to distributing questionnaires at pre-participation physicals, pre-season parent meetings, or individual team

meetings. Athletes who scored less than or equal to 23 on the CAIT were identified as having FAI. Frequencies were calculated to determine the overall prevalence and percentage of unilateral and bilateral FAI. Separate Chi-square test of independence was calculated comparing the frequency of FAI in men and women and in high school and college athletes. **Main Outcome Measures:** Presence or absence of FAI were the dependent variables. **Results:** Of all participants, 23.4% were identified as having FAI, half of these participants had FAI bilaterally and the remainder had unilateral FAI. High school athletes are more likely to have FAI than their collegiate counterparts ($x^2(1)=10.45$, $p<.001$). Specifically 31.1% of the surveyed high school athletes had FAI (13.3% had unilateral FAI and 17.9% had bilateral FAI) while only 18.7% of the college athletes had FAI (10.8% had unilateral FAI and 7.9 had bilateral FAI). FAI was also more prevalent among women than men in both high school ($x^2(1)=5.01$, $p=.01$) and collegiate settings ($x^2(1)=10.13$, $p=.01$). Overall, 32.1% of the women in this study were identified as having FAI, compared to only 17.4% of the men. **Conclusions:** A higher percentage of both unilateral and bilateral FAI exists among high school and female athletes. Athletic trainers, physicians and coaches should pay special attention to these populations as they are at a higher risk for developing FAI.

Does Severity Of A Previous Ankle Injury Influence Region-Specific And Generic Health-Related Quality Of Life In Collegiate Athletes?

Lam KC, Bay RC: A.T. Still University, Mesa, AZ

Context: Health-related quality of life (HRQOL) characterizes the impact an injury, condition, or treatment has on various health domains (eg, physical, emotional, social) from the patient's point-of-view. Previous findings in college athletes suggest that a positive knee injury history may negatively impact knee-specific HRQOL but not generic HRQOL. It is unknown if similar findings exist in individuals with a previous ankle injury. **Objective:** To determine whether region-specific (Foot and Ankle Ability Measure [FAAM]) and generic (Short Form 12 [SF-12]) HRQOL differs in collegiate athletes based on the severity of a previous ankle injury. **Design:** Cross-sectional. **Setting:** Athletic training facilities. **Patients or Other Participants:** Two hundred and seventy-two intercollegiate athletes, who were medically cleared for full participation, were included in the study. Sixty-five athletes reported a previous severe ankle injury (SAI), defined as an injury causing loss of participation for e"10 days (male=32, female=33, age=19.5±1.6 years, height=175.8±10.7 cm, mass= 72.0±12.4 kg), 63 reported a previous mild ankle injury (MAI), defined as an injury causing loss of participation for >1 but <10 days (male=32, female=31, age=19.1±1.2 years, height=174.6±10.9 cm, mass= 69.4±12.2 kg), and 144 reported no previous ankle injury (NAI) (male=85, female=59, age=19.4±1.5 years, height=175.3±11.7 cm, mass= 71.7±13.0 kg). **Interventions:** The independent variable was injury history group. Participants completed the FAAM (21 items) and SF-12 (12 items) during a single testing session. **Main Outcome Measures:** Dependent variables included the FAAM total score and the 8 SF-12 subscale scores (Physical Functioning [PF], Role Physical [RP], Bodily Pain [BP], General Health [GH], Vitality [VT], Social Functioning [SOF], Role Emotional [RE], Mental Health [MH]). All scores range from 0-100, with higher scores indicating better HRQOL. Generalized linear models were used for group comparisons. Group differences were evaluated with pairwise comparisons (Bonferroni), pd".05. **Results:** Significant differences were reported for the FAAM total score ($p<.001$, SAI=94.7±0.7, MAI=98.0±0.7, NAI =99.7±.5), RP ($p=.02$, SAI=87.1±1.9, MAI=91.8±1.9, NAI=93.4±1.2), BP ($p=.04$, SAI=79.2±3.0, MAI =86.9 ±3.0, NAI=88.4±2.0), MH ($p=.04$, SAI=72.3±2.2, MAI=79.2±2.2, NAI =78.3±1.5). Pairwise comparison reported group differences between the SAI and NAI groups but no differences for the MAI group when compared to other groups. No group differences ($p>.05$) were reported for the remaining SF-12 subscales: PF (SAI=96.2±1.2, MAI=98.1±1.2, NAI=97.2±0.8), GH (SAI=85.5±2.0, MAI=82.5±1.9, NAI=85.0±1.3), VT (SAI=66.8±2.5, MAI=72.0±2.5, NAI=69.0±1.6), SOF (SAI=84.4±2.7, MAI=88.6±2.6, NAI=88.2±1.7), RE (SAI=88.1±2.0, MAI=91.7±2.0, NAI=90.6±1.3). **Conclusions:** Despite returning to full participation, individuals with a previous SAI tend to report difficulties completing activities of daily living (ADL), more pain with ADLs, and lower mental health satisfaction than individuals with no ankle injury history. Our findings suggest that, unlike previous knee injuries, previous ankle injuries can negatively impact both region-specific and generic HRQOL. Clinicians should be aware that individuals with a previous SAI may continue to experience HRQOL deficits despite being medically cleared for full participation.

The Severity Of A Previous Ankle Injury Does Not Impact Postural Control

Williams TA, Kulow SM, Valovich McLeod TC, Lam KC: A.T. Still University, Mesa, AZ

Context: The evaluation of postural control is an important component to the management of sport-related injuries. While current evidence indicates that postural control is negatively impacted by a previous ankle injury and chronic ankle instability, it is unknown whether the severity of a previous ankle injury, based upon total time loss, influences postural control. **Objective:** To determine whether the severity of a previous ankle injury impacts postural control as measured by the Stability Evaluation Test (SET), an instrumented version of the Balance Error Scoring System (BESS). **Design:** Cross-sectional. **Setting:** Athletic training facilities. **Patients or Other Participants:** Intercollegiate athletes who had a history of a severe ankle injury (SAI), defined as an injury causing loss of participation for e"10 days (male=12, female=26, age=19.3±1.3 years, height =173.3 ±10.1 cm, mass=69.0±10.2 kg), a mild ankle injury (MAI), defined as an injury causing loss of participation for >1 but <10 days (male=19, female=18, age=19.2±1.2 years, height=176.0±12.2 cm, mass= 69.5±13.2 kg), and no ankle injury (NAI) (male=52, female=35, age=19.4±1.4 years, height= 175.5 ±11.4 cm, mass=72.1±13.0 kg). All participants were medically cleared for participation with no restrictions. **Interventions:** The independent variable was injury history group. Participants completed the SET, a series of 20-second balance tests on a portable force plate under the six BESS stance conditions: double-leg firm (DFi), single-leg firm (SFi), tandem firm, (TFi), double-leg foam (DFo), single-leg foam (SFo), and tandem foam (TFo). **Main Outcome Measures:** Dependent variables included sway velocity (SV) and BESS error scores (ES) for each stance condition. SV (deg/sec) was defined as the ratio of the distance traveled by the center of gravity to the time of the trial. ES were counts of errors committed during each condition. Generalized linear models were utilized for group comparisons and group differences were further evaluated with pairwise comparisons (Bonferroni), $p<.05$. **Results:** Significant group differences were reported for SV ($p=.001$) and ES ($p=.01$) for the TFo condition. Pairwise comparisons indicated that the SAI group (SV=6.35±0.34, ES=5.13±0.39) demonstrated significantly higher SV and ES than the NAI group (SV=4.79±0.28, ES=3.78±0.26). No significant differences were found when comparing the MAI (SV=5.53±0.35, ES=4.11±0.39) with the SAI or the NAI group. No other group differences were reported for the remaining conditions for SV ($p<.13$) or ES ($p<.13$). **Conclusions:** Our findings suggest that the severity of a previous ankle injury does not generally impact postural control when measured by the SET or the BESS. Differences reported between the SAI group and NAI group suggest that the TFo stance may be useful in identifying potential postural control deficits in collegiate athletes. Future investigations should determine whether postural control deficits demonstrated in the TFo stance condition are clinically significant (eg, predisposes the individual to an ankle or lower extremity injury).

Self-Perceived Ankle Instability Correlates With Poor Clinical Balance Assessments

Linens SW, Ross SE, Arnold BL: Georgia State University, Atlanta, GA; University of North Carolina at Greensboro, Greensboro, NC; Virginia Commonwealth University, Richmond, VA

Context: A variety of balance tests have differentiated stable and unstable ankles. However, few studies have determined the relationship between self-reported instability and clinical balance measures associated with chronic ankle instability (CAI). **Objective:** To investigate the relationship between self-perceived ankle instability with clinical balance measures. **Design:** Correlational. **Setting:** Laboratory. **Participants:** CAI subjects had a history of ankle sprains and symptoms of "giving way" (N=17; 168±9 cm; 68±12 kg; 23±4 yrs) and stable ankle subjects (SA) had no history of ankle injuries (N=17; 168±8 cm; 66±12 kg; 23±3 yrs). **Interventions:** Self-perceived ankle instability was measured using the Cumberland Ankle Instability Tool (CAIT). CAI and SA subjects performed single leg balance on the injured leg or a side matched leg, respectively. Subjects performed 4 clinical balance tests: 1) Time-In-Balance (TIB); 2) Foot Lift Test (FLT); 3) Star Excursion Balance Test (SEBT) in posteromedial reach direction; and 4) Side-To-Side Hop (SSH). For TIB, subjects stood on the test leg with their eyes closed for up to 60 s. Subjects' time-in-balance was recorded as the time when balance was lost by touching down with non-weight bearing leg or as 60 s if they remained balanced. The FLT required subjects to stand on the test leg for 30 s with eyes closed. The number of times a part of the foot was lifted or the contralateral foot touched down were tallied. The SEBT required subjects to stand on their test leg and reach for

maximum distance with the contralateral leg in posteromedial direction. For the SSH subjects completed 10 side-to-side 30 cm hops as quickly as possible. Balance tests were counterbalanced. Pearson product-moment correlations were calculated between CAIT scores and each balance measure. Alpha level was set a priori (0.05). **Main Outcome Measures:** The degree of perceived ankle instability was quantified with total score on CAIT (lesser scores=greater instability). Balance was quantified with length of time balancing (s) for TIB, frequency of foot lifts (score) for FLT, distance reached (normalized to leg length) for SEBT, and time (s) to complete SSH. Poor balance was indicated by less time-in-balance, greater frequency of foot lifts, shorter reach distance on SEBT, and longer time to complete side hops. **Results:** Significant Pearson product-moment correlation coefficients were found between CAIT and TIB ($r=-0.35$, $P< 0.05$) and FLT ($r=.43$; $P< 0.05$). No correlation ($P>.05$) was found between CAIT and SEBT ($r=0.32$) or SSH ($r=-0.23$). **Conclusions:** While each test can be used to identify balance deficits associated with CAI, the TIB and FLT are the only balance tests that have a relationship with self-perceived feelings of instability. Our results also indicate that among clinical tests static balance measures are more indicative of self-perceived instability than dynamic balance measures.

Ankle Evidence-Based Forum

Tuesday, June 25, 2013, 2:45PM-3:45PM; Palm C; Moderators:

Free Communications, Oral and Thematic Presentations: Abdominal Conditions Case Studies

Wednesday, June 26, 2013, 8:00AM-8:45AM; Palm C; Moderator: Michael Milligan, MD, CAQSM

Abdominal Pain In A Collegiate Softball Player

Pouliot S, Rothbard M, Geiger A: Southern Connecticut State University, New Haven, CT

Background: A 22 year-old female softball player presented to the athletic trainer with abdominal pain, nausea, constipation, post-prandial fullness, and unexplained 12.73kg weight loss equaling 22% of her body weight over a four-month period. The pain was described as severe, constant, and unbearable upon ingestion of food. Initial examination by the athletic trainer revealed abdominal bloating, palpable tenderness, and weak pulses. The patient's previous medical history was significant for idiopathic abdominal pain for four years prior and status-post five months cholecystectomy. **Differential Diagnosis:** intestinal cancer, ovarian cancer, ovarian cysts, Crohn's disease, Ciliac disease, and gastroparesis. **Treatment:** Upon examination, she was disqualified from athletic participation and was referred to a PCP. Physician examination confirmed the athletic trainer's findings and ordered a vaginal ultrasound that identified ovarian cysts, and an abdominal CT scan that revealed intestinal inflammation indicating the possibility of cancerous cells. A second CT-scan with contrast was unremarkable, ruling out cancer. The patient was referred to a gastroenterologist for additional testing. An endoscopy and colonoscopy were performed. Results were unremarkable. A 90-minute gastric emptying test was then performed, which demonstrated significant delayed gastric emptying. A preliminarily diagnoses of gastroparesis was made. Erythromycin was prescribed to facilitate intestinal motility, which had no effect on her symptoms. With her condition deteriorating the athletic trainer referred the patient to the hospital. While hospitalized for two weeks, a brachial PICC line insertion for TPN feeding was established, which stabilized her condition. After discharge and consultation, she was referred to a motility specialist and was admitted to a different hospital. A four-hour gastric emptying scintigraphy test was administered. After one hour, 90% of the food remained in her stomach. After four hours, 75% remained, confirming gastroparesis. To improve intestinal motility she was prescribed 10mg of Domperidone® bid, which was progressively increased over four days to 20mg tid, but with no improvement. An MRA was ordered, identifying abdominal vascular damage. Specifically, the median arcuate ligament appeared to be blocking the inferior mesenteric artery and vagus nerve, causing diminished blood flow and nerve signals to the stomach. Two days post-discharge, the PICC line appeared to be infected, the patient displayed signs of renal failure, and she was referred back to the hospital. The PICC line was removed. She underwent surgery for a Jejunostomy tube insertion providing 1560 mL of Vital AF 1.2 Cal™ every day and was released from the hospital one week later. During a follow-up consultation by the athletic trainer, the patient was permanently disqualified from athletic participation based on her condition and augmented nutritional intake. Status post 8 months, a Mickey tube was inserted to replace the Jejunostomy tube, which is expected to remain in place indefinitely. **Uniqueness:** Gastroparesis is a rare disorder with an incident rate of 0.0001% in non-diabetics; however, it typically affects people with long-term diabetes and females over the age of 30. Also, the patient did not present with other risk factors associated with gastroparesis, which include systemic sclerosis, hypothyroidism, and anticholinergic, narcotic and antidepressant medications. **Conclusion:** Gastroparesis is a condition that inhibits gastric emptying without an intestinal blockage. In this case, it appeared that a vascular and neuromuscular dysfunction limited gastric emptying, and food never reached the intestines for further digestion and absorption. Gastroparesis has a poor prognosis and significantly impacts the life and daily activities of those affected. Although gastroparesis is generally incurable, effective communication by the patient, athletic trainers, and physicians and highly specialized prompt medical care helped save her life. This case presented unique challenges in recognizing, treating, and managing this patient who must live and cope with this lifelong debilitating condition.

Ulcerative Colitis In A High School Football Player

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Background: This case involves a 16-year-old varsity high school football player (height: 172.7 cm weight: 73.5 kg) at the position of free safety. This athlete had no previous history of chronic illnesses or injury prior to the current condition; however, his family history revealed that one of his relatives has Crohn's Disease. During summer break, the athlete went on vacation and became ill upon his return. The athlete presented with bloody diarrhea and abdominal pain 7 weeks before preseason football. He continued to experience diarrhea and lost a significant amount of weight, weighing 63.5 kg. He was taken to the hospital and placed on the antibiotic Flaggyl for 4-6 weeks. After 6 weeks, he experienced bloody stool again and was taken to the hospital and admitted for 5 days. The hospital admittance occurred one week before the start of preseason football. **Differential Diagnosis**: Intestinal infection, ulcerative colitis, Crohn's disease, irritable bowel syndrome **Treatment**: A colonoscopy during the second hospital visit revealed ulcers lining the colon, leading to a diagnosis of ulcerative colitis. The athlete was placed on the steroid Asacol to decrease the inflammation of his colon and reduce diarrhea. He was not cleared for activity until stool was clear of blood. During this time, his appetite increased, and he began trying to gain weight. A strict diet and adequate hydration helped achieve weight gain. Fatigue was a limiting factor in ADLs; however, he was cleared to participate in conditioning activities with the football team during the second week of preseason. The athletic trainer designed a rehabilitation program consisting of cardiovascular conditioning and full body strength training, which the athlete completed as tolerated. When the athlete began this rehabilitation, his total weight loss was approximately 10.0 kg (~ 22 lbs). During reconditioning, the athlete often reported feelings of depression, fear and anxiety to the athletic trainer. The athlete also experienced frequent, intense, uncontrollable urges to go to the bathroom that often interrupted school, practice, games and rehabilitation. The athlete also experienced an accident in school, which devastated his rehabilitation process and psyche. Finally, after approximately 12 weeks, he received clearance from a pediatric gastrointestinal specialist and was given a new medication regimen (Cimzia, a once-monthly subcutaneous injection). At this time, he was then able to complete a full week of football practice and participate in the third game of the season. His weight increased to 70.3 kg, and he was able to participate as a starter for the fifth football game. Throughout the remainder of the season, his weight loss from the diarrhea was controlled by the Cimzia injections; however, he still suffered from occasional bouts of diarrhea and abdominal pain. **Uniqueness**: This disease is rarely seen in adolescent athletes. Ulcerative colitis is a genetic condition that will last the athlete's lifetime. The management of ulcerative colitis is difficult in the initial stages; in particular, the combination of this condition with athletic activity made it more challenging for the athlete to return to ADLs. The infection that triggered the disease was Aeromonas sobria, found in contaminated water and fish and was contracted while the athlete was on vacation. **Conclusions**: For an adolescent, ulcerative colitis can be a devastating condition. The athletic trainer should be empathetic and understanding when dealing with this athlete. It is necessary to form a plan and communicate this plan with the athlete, parents, coaches, teachers and guidance counselors. This plan should include education about the condition, excused trips to the bathroom during class/practice without asking, ensuring proper hydration and nutrition, core strengthening and cardiovascular conditioning, and proper storage of medications at the school.

Residual Stump Appendicitis in the Competitive Athlete: A Case Report

Bonnett JH, Smith JJ, Watson DJ: University of Delaware, Newark, DE

Background: Following a 7 to 10 day period of non-specific abdominal pain, a 19 year-old male intercollegiate football player underwent a laparoscopic appendectomy for a ruptured appendix. Surgeons found inflammation and infection throughout the abdominal cavity along with a gangrenous appendix. One week later he had a Computed Tomography (CT) guided drainage of two pelvic abscesses containing murky fluid. The athlete was cleared for return-to-play progression three weeks later and began progressively increasing conditioning and strength training exercises in preparation for return to football practice. Approximately 8 weeks after the initial appendectomy, the athlete reported to the athletic training room presenting with right-sided flank pain. The athlete reported that the previous training session had been an upper body work-out focusing on chest, arms, back and core musculature. A physical examination revealed rebound tenderness in the right upper and lower quadrants and nausea with no other acute distress. His bowel sounds were diminished. The athlete was sent by the Team Physician for a CT scan of the abdomen and pelvis with intravenous contrast. Imaging showed inflammation and increased free fluid in the abdomen and a 10 millimeter tubular structure in the pericecal area. Following consultation with the general surgeon, it was believed that the inflammation was a result of the original appendicitis. The athlete was administered oral antibiotics in order to control the infection. Two days later, the athlete reported increased pain and he was referred to the general surgeon and admitted to the hospital for intravenous antibiotics. **Differential Diagnosis:** Abdominal abscess, Post-surgical adhesions, Peritonitis, Cholecystitis, Kidney stone, Ruptured bowel, Muscle strain **Treatment:** On the day of admission, the athlete underwent laparoscopic exploration of the abdominal cavity including irrigation and drainage. Surgeons found a residual, several millimeter long tip of the original appendix adhered to the colon which they then excised. The post-operative diagnosis was residual stump appendicitis and abdominal abscess. The athlete was discharged two days later following an uneventful recovery. Over the past eight weeks, his activity has gradually increased to light running and lifting while paying special attention to any signs of abdominal pain or abnormalities. Upon clearance from his surgeon, the athlete will begin full-contact football drills. No more complications have occurred and the athlete continues to progress through his return-to-play protocol. **Uniqueness:** Residual stump appendicitis is a residual inflammation of the remnants of a removed appendix. It is a rare, underreported condition. Of those previous cases, there is only one other case where surgeons found a residual tip of the appendix. This case involved a middle-aged adult rather than a competitive young athlete. Further, the reported time frame for the development of this condition ranges from 2 months to 50 years. This case presented with an accelerated time frame, likely due to the demands on the body as a result of participation in intercollegiate athletics. **Conclusions:** In this case, a young, competitive athlete with a recent appendectomy presented with acute abdominal symptoms including rebound tenderness and nausea which proved to be residual stump appendicitis. For the clinician who is faced with an athlete presenting with abdominal pain, nausea, and vomiting, who has recently had an abdominal surgery, there are many common causes that should be considered, both surgical and non-surgical. Conditions not related to previous surgery could include kidney stones, cholecystitis, muscle strains, and bowel obstruction. Surgically related diagnoses for abdominal pain may include abdominal abscess, post-surgical adhesions, and peritonitis. Sports health care professionals should consider residual stump appendicitis in the differential diagnosis for all athletes with a previous history of appendectomy.

Free Communications, Oral Presentations: Impact of Preseason on Exertional Heat Illness

Wednesday, June 26, 2013, 9:15AM-10:15AM; Palm C; Moderator: Kristin Kucera, PhD, ATC

The Georgia Study: The Risk of Exertional Heat Illnesses in High School Players

Ferrara MS, Cooper ER, Miles JD, Curry PR, Grundstein A, Casa D, Powell JP: The University of Georgia, Athens, GA

Context: Exertional heat illness (EHI) is a fairly common occurrence in football particularly in the first couple of weeks of the pre-season with heat cramps accounting for about 75% of all EHI cases while heat exhaustion and heat syncope (HS/HE) accounted for the remaining 25%. Numerous investigators have posed various preventive measures to reduce the rate of EHI but it is difficult to develop a direct cause and effect relationship between variables and reducing the illness rate. The purpose of this study was to evaluate the incidence rates of EHI's during football and to determine if there was a relationship between the rate of EHI, the week of practice and the environment. **Design:** Prospective observational epidemiological design. **Setting:** Interscholastic (IS) institutions (Georgia High School Association members) representing 5 geographical regions (North, Central, Metro Atlanta, Southeast, and Southwest). **Participants:** IS football players from 23 schools in the state of Georgia for the 2009 – 2011 seasons, during the months of August and September. **Interventions:** EHI types were recorded by athletic trainers for their respective schools. EHI definitions were based on the NATA position statement: heat cramps (HC), heat exhaustion (HE), heat syncope (HS), and heat stroke (STR). There were no recorded STR's during the 3-year period. **Main Outcome Measures:** EHI's were recorded during all practice, conditioning, and game activities held during the 3-year reporting period. Any EHI that resulted in a participant being restricted from continuation of activity constituted an occurrence. The overall EHI's was calculated and the HS and HE variables were combined into one variable (HS/HE). IR was calculated with 95% confidence intervals (CI). **Results:** There were 651 reported EHI occurrences with 200,937 athlete-exposures (AE) recorded for an overall IR of 3.24/1000AE (95%CI=3.00, 3.50). For HS/HE, there were a total of 174 reported cases for an overall IR of 0.87/1000AE (95%CI=0.74, 1.00). We founds that 49% (IR=1.84/1000AE; 95% CI=1.46, 2.29) of the HS/HE cases occurred during the first week of practice 23% (IR=1.55/1000AE; 95%CI=1.10, 2.12) in week 2, 11% (IR=0.74/1000AE; 95%CI =0.44, 1.17) in week 3 and 9% (IR=0.63/1000AE; 95%CI=0.35, 1.06) in week 4. We also found that 79% of the EHI's occurred at a WBGT less than 30^0C WBGT during the course of the project and for the first week of practice, 61% of the EHI's occurred at a WBGT of less than 30^0C. **Conclusion:** To our knowledge, this was the first ever, large-scale study directly relating to IS football players where EHI was related to WBGT. This data is of paramount importance in seeking to determine where the risks are greatest and what variables may be changed or manipulated to make sport activities in the pre-season period safer for the participants. We found that the significant EHI cases (HS/HE) occurred during the first 2 weeks of practice at WBGT that is not considered extreme. As EHI policies are developed, the first two weeks provided the greatest risk of HS/HE case and all preventive measures should be employed to mitigate these risks.

Athletic Trainer Staff Size, Number Of Exertional Heat Illness Events, And Use Of Exertional Heat Illness Prevention Strategies In US High School Football Programs

Kerr ZY, Casa DJ, Comstock RD, Marshall SW: University of North Carolina, Chapel Hill, NC; University of Connecticut, Storrs, CT; The Research Institute at Nationwide Children's Hospital, Columbus, OH

Context: An estimated 6,500 high school football student-athletes are treated annually for exertional heat illness (EHI). Variable athletic trainer (AT) coverage may lead to disparities in implementing EHI prevention strategies. Lack of AT coverage may also lead to an increase in the frequency of EHI events. **Objective:** To compare the prevalence of EHI prevention strategies and number of EHI events in the 2011 high school football pre-season between high school programs staffed by one AT versus multiple ATs. **Design:** Cross-sectional study. **Setting:** NATA-affiliated ATs providing care to high school football student-athletes during the 2011 pre-season. **Patients or Other Participants:** We contacted 6,343 ATs that provided care to football student-athletes in the 2011 pre-season from a membership list provided by the NATA. ATs completed the online questionnaire (n=1,137; 17.9%). Our sample represented ATs from all 50 US states except Alaska and Rhode Island, states not considered high risk for pre-season EHI events. Most were male (51.8%), had over 10 years experience (57.9%), and had an average age of 37.0 years (±10.2). **Interventions:** ATs answered questions via an online questionnaire pertaining to: number of ATs, high schools' demographics, EHI prevention strategies implemented (e.g., cold water immersion,

monitoring ambient temperature, etc.), and number of EHI events in the 2011 pre-season. We categorized our respondents based as ATs working by themselves ("Solo"; n=221) during the 2011 pre-season or those reporting additional staff ("Assisted"; n=916). Additional staff included high school/college student AT assistants, volunteer ATs, or staff/volunteer physicians. **Main Outcome Measures:** Using independent sample t-tests, we compared the number of implemented EHI prevention strategies and number of treated EHI events between "Solo" and "Assisted" ATs. Using chi-square tests, we compared the prevalence of specific EHI prevention strategies implemented between "Solo" and "Assisted" ATs. **Results:** In the 2011 football pre-season, ATs utilized 7.6 ± 2.5 different EHI prevention strategies and 0.5 ±1.4 EHI events were treated per high school football program. The numbers of EHI prevention strategies and EHI events were positively correlated (P=0.02). "Assisted" ATs utilized more EHI prevention strategies than "Solo" ATs (7.9 vs. 6.5; P<0.001). Assisted ATs were more likely to use the following EHI prevention strategies than "Solo" ATs: "Checked environmental temperature" (75.9% vs. 59.7%; P<0.001); and "Filled immersion tub with ice water prior to start of practice" (48.9% vs. 26.7%; P<0.001). "Assisted" and "Solo" ATs did not differ in the number of EHI events treated in the 2011 pre-season (0.52 vs. 0.44 per program; P=0.39). **Conclusions:** Although considered a rare event, a high number of EHI events occurred during the pre-season. High school football programs must ensure that AT staff, regardless of their number, have adequate resources to implement EHI prevention strategies, and are well trained to identify and manage EHI. *Study funded in part by Society for Public Health Education/CDC Student 2012 Fellowship in Injury/Violence Prevention and Control.*

Demographics of Exertional Heat Illnesses Among Interscholastic Football Athletes During August/September: A 3-Year Study

Cooper ER, Miles JD, Curry PJ, Grundstein A, Ferrara MS: The University of Georgia, Athens, GA

Context: American interscholastic (IS) football players encounter many different illnesses/injuries during pre-season practice sessions in the summer months. Exertional heat illness (EHI) is one area of concern. Questions have been raised as to whether or not these EHI occurrence risk rates vary among player demographics; academic class of the participants, their specific position on the team, and the level of play. **Objective:** To determine who is sustaining EHI's among IS football participants with respect to academic rank, player position, and level of participation on the team for IS institutions in the state of Georgia. **Design:** Prospective observational epidemiological design. **Setting:** Interscholastic institutions (Georgia High School Association members) representing 5 geographical districts (North, Central, Metro Atlanta, Southeast, and Southwest). **Participants:** IS football players from 23 schools in the state of Georgia for the 2009 – 2011 seasons, during the months of August and September. **Interventions:** EHI types were recorded by athletic trainers for their respective schools. EHI definitions were based on the NATA position statement: heat cramps (HC), heat exhaustion (HE), heat syncope (HS), and heat stroke (STR). There were no recorded STR's during the 3-year period. Overall EHI's (OEHI), HC and significant EHI's (HS and HE were tabulated as one variable due to low numbers of HS) were calculated (SEHU). **Main Outcome Measures:** EHI's were recorded during all practice, conditioning, and game activities held during the 2 month reporting period. Any EHI that resulted in a participant being restricted from continuation of activity constituted an occurrence. **Results:** A total of 652 EHI's (477 HC, 175 SEHI's) were recorded over the 3-year period. Percent of overall OEHI and percent of SEHI cases reported by academic class were: freshman (OEHI=11%, SEHI=18%), sophomore (OEHI=23%, SEHI= 30%), juniors (OEHI=26%, SEHI= 26%) and seniors (OEHI=40%, SEHI=26%). By offensive player position, lineman had the greatest number of episodes (OEHI=35%, SEHI=51%), followed by running backs (OEHI=31%, SEHI=22%) and wide receivers (OEHI=20%, SEHI=16%). Defensively, lineman once again had the greatest occurrences (OEHI=39%, SEHI= 61%), followed by defensive backs (OEHI=34%, SEHI=18%) and linebackers (OEHI=28%, SEHI= 21%). Level of play indicated that "starters" represented the largest number of recorded EHI's (OEHI =72%, SEHI=54%), followed by "substitutes" (OEHI=27%, SEHI =45%) and non-players (OEHI=1%, SEHI=1%). **Conclusion:** This data demonstrates specific player characteristics which can be used by the athletic trainer to determine higher risk populations to monitor during pre-season, regular practice sessions and games. Observationally, linemen (offensive & defensive) experience a higher number of SEHI's than all other positions. In addition, participants who are labeled "starters" had a greater occurrence of OEHI than "substitutes", however the risk for SEHI's were similar between these two groups. Athletic trainers can use this data to formulate strategies to reduce EHI occurrence among these target groups. This project was funded by the NATA Research & Education Foundation.

Acclimatization In Georgia Interscholastic Football Players: A Three-Year Perspective

Miles JD, Curry PJ, Cooper ER, Grundstein AJ, Ferrara MS: The University of Georgia, Athens, GA

Context: Proper acclimatization can mitigate the risk of exertional heat illness (EHI) during the pre-season period. Physiologic changes due to acclimatization begin to take place within the first 3-5 days of heat exposure and continue for up to 2-3 months. However, there have been minimal field-based studies to determine the actual acclimatization period for interscholastic (IS) football players. **Objective**: To evaluate acclimatization trends in IS football players in Georgia. **Design:** Prospective epidemiological design. **Setting:** Interscholastic institutions from 5 geographic regions in the state of Georgia (North, Metro Atlanta, Central, Southeast, Southwest) **Participants:** IS football athletes from 23 schools in Georgia for August, 2009-2011 seasons. **Interventions:** An ATC was identified at each school and recorded all athlete-exposure (AE), EHI, and practice duration data. EHI types were identified as heat cramps (HC), heat exhaustion (HE), heat syncope (HS), and heat stroke (STR) as defined by the National Athletic Trainers' Association Position Statement. Due to the low number of HS's, HS and HE were combined to form one variable (HS/HE). **Main Outcome Measures:** The dependent variable was EHI occurrences (HS/HE) and the independent variables were practice week and practice duration. Injury rates (IR) were calculated using the following equation: number of injuries/number of athlete exposures (AE) x 1000 with 95% confidence intervals (CI). **Results:** In August, there were 141 HS/HE's recorded and 106,782AE for three seasons resulting in an overall IR of 1.32/1000AE (95%CI=1.10, 1.54). IR's for HS/HE were highest in week 1, 1.84/1000AE (95%CI=1.45, 2.30) and were 1/3 of that by week 4, 0.63/1000AE (95%CI=0.34, 1.09). During week one, the IR was 1.04/1000AE (95%CI=0.53, 1.85) for practices <120 min., but the rate increased 2.5 times for practices lasting 120-150 min. (2.41/1000AE, 95%CI=1.61, 3.48) and increased 4.5 times for practices lasting e"3 hrs. (4.72/1000AE, 95%CI=1.79, 5.15). For week two of practice, the IR was 0.50/1000AE (95%CI=0.16, 1.20) for practices lasting up to 150 min., showing 30 minutes of acclimatization. For the third week, another 30 minutes of acclimatization was seen for a 180-minute practice session (0.85/1000AE, 95%CI =0.58, 1.21). **Conclusion:** These data are the first to demonstrate acclimatization in adolescents in a field-based setting. The first two weeks of practice had the greatest risk of EHI. For the first week, practices lasting longer than 120 minutes, and those lasting longer than150 minutes in the second week demonstrated an increased risk. Importantly, these data show acclimatization from the first week to the second week, with both a decrease in the HS/HE IR's from week 1 to week 4 along with athletes' ability to acclimatize, withstanding an additional 30 minutes of practice per week through. Athletic Trainers and other authorities should use this data to create acclimatization guidelines for football, decreasing serious EHI events. This project was funded by the NATA Research & Education Foundation.

A Climate Assessment Of Best Football Practice Times

Grundstein A, Cooper E, Miles JD, Curry PR, Ferrara MS: University of Georgia, Athens, GA

Context: Football players are among the most susceptible athletes to heat-related illnesses. Practices are variously held in the morning and/or afternoon but no study has examined from a climate perspective which time of the day provides the safest training conditions with regard to heat exposure. **Objective:** To determine the best times to schedule football practices to minimize exposure to oppressive heat. **Design:** Observational study. **Setting:** Weather stations across the United States. **Patients or Other Participants:** None. **Interventions:** A 15-year climatology (1991-2005) of August wet bulb globe temperatures (WBGT) was computed for 217 locations across the contiguous United States using weather station observations and a physically-based WBGT model. **Main Outcome Measures:** The ACSM (2007) WBGT guidelines were used to determine the risk categories. We examined six, 3-hour training session times (6-9 a.m., 7-10 a.m., 8-11 a.m., 3-6 p.m., 4-7 p.m., 5-8 p.m. LDT) to identify how the WBGT varies with the time of day the practice session was held and how frequently the WBGT during those sessions exceeded key ACSM safety thresholds where practices would need to be limited (30.1°C) or canceled (32.3°C). **Results:** Across the country, morning practices had lower WBGT values and a lower frequency of exceeding ACSM safety standards than afternoon practice times. Climatologically, WBGTs were lowest for 6-9 a.m. practices and greatest for those at 3-6 p.m., with WBGT values averaging almost 7°C greater during the 3-6 p.m. session. Starting a morning practice one (two) hours after 6 a.m. increased the WBGT by an average of 1.7±0.5°C

(3.7±0.9°C). Importantly, only a small percentage of hours (<2.5%) exceeded the critical 32.3°C threshold for canceling practice at any station for 6-9 a.m. sessions, increasing up to a maximum of 10% between 8-11 a.m. Afternoon practice sessions more frequently exceeded safety standards with some locations experiencing up to 20% (66%) of hours exceeding the 32.3°C (30.1°C) thresholds. Starting the practice session one (two) hours after 3 p.m., resulted in an average decrease in WBGT of 0.8±0.2°C (1.9±0.3°C). Further, delaying the start time by one (two) hours decreased the percentage of exceedance relative to the 3-6 p.m. period by 40±9% (70±9%) for the 32.3°C threshold and 35±6% (66±8%) for the 30.1°C threshold for those stations (+1 standard deviation) with the greatest percentage of hours that exceeded the ACSM thresholds. **Conclusions:** Climatologically, mornings from 6-9 a.m. are the best times to practice to minimize exposure to oppressive heat. While afternoons are hotter, delaying the start of practice a few hours may substantially reduce the likelihood of oppressive conditions and the probability of a practice being limited or cancelled.

Heat & Hydration Evidence-Based Forum

Wednesday, June 26, 2013, 10:30AM-11:30AM; Palm C; Moderator:

The Effects Of Kinesio Taping® On Postural Control Deficits In Healthy Ankles, Copers, And Individuals With Functional Ankle Instability

Shields C, Needle AR, Rose WC, Swanik CB, Kaminski TW: University of Delaware, Newark, DE

Context: Ankle sprains are the most common injury among physically active people, with common sequelae including functional ankle instability (FAI). Copers are a cohort who have sprained their ankle but not suffered any further dysfunction. Kinesio® Tape has emerged as a technique that may improve joint stability; however, limited research has investigated its efficacy among injured populations. **Objective:** To examine the immediate and prolonged effects of Kinesio Taping® on postural control in healthy, coper, and functionally unstable ankles. **Design:** Cross-sectional study. **Setting:** Athletic training research laboratory. **Patients or Other Participants:** Sixty physically active, college-aged participants (35 females, 25 males, height=72.5±9.7cm, mass=74.2±16.2kg, age=21.5±2.6yrs.) participated in this study. Subjects were stratified into healthy, coper, or FAI using the Cumberland Ankle Instability Tool and history of ankle sprain. **Interventions:** Each participant performed 20-second single-limb balance trials on a force plate with eyes closed. Testing was performed prior to tape application (PRE), immediately following (KT-I), at 24-hours (KT-24), and immediately after tape removal (POST). Separate 2-way repeated-measures ANOVA's (p£ 0.05) were conducted comparing group and tape condition. Pairwise comparisons were used for post-hoc analysis with a Bonferroni correction to control for multiple comparisons. Cohen's d effect sizes (ES) were calculated for statistically significant measures. **Main Outcome Measures:** Independent variables included group and tape condition; while dependent variables included time-to-boundary (TTB) and traditional center-of-pressure (COP) measures in both the mediolateral (ML) and antero-posterior (AP) planes. **Results:** Significant differences between groups were observed for AP COP standard deviation ($F_{2,57}$=4.31, p=0.018) and range ($F_{2,57}$=4.92, p=0.011). Significant differences between tape conditions for ML TTB absolute minima ($F_{3,159}$=3.61, p=0.015) and standard deviation ($F_{3,138}$=5.71, p=0.002), and AP TTB standard deviation ($F_{3,141}$=3.32, p=0.029) were also observed. Pairwise comparisons revealed large to medium effect sizes for group differences and small effect sizes for differences across tape conditions. FAI displayed higher COP standard deviation (healthy=0.012±0.002m, FAI=0.014±0.003m, p=0.027, ES =0.56) and range (healthy =0.065±0.012m, FAI= 0.075± 0.017m, p=0.021, ES=0.83) compared to healthy ankles, as well as increased COP range compared to copers (copers=0.065±0.012m, p=0.033, ES=0.83). Improvements were observed in ML TTB absolute minima from PRE (0.116±0.064s) to KT-24 (0.133±.065s, p=0.025, ES=0.15), as well as, increases in ML TTB standard deviation from KT-I (1.975±1.786s) to KT-24 (0.926 ±0.486s, p=0.002, ES=0.14) and from KT-24 to POST (1.780±1.696s, p=0.009, ES=0.06). **Conclusions:** As functionally unstable ankles demonstrated diminished postural control using traditional COP measures, our data support the use of these variables for identifying impairments among this subset. Furthermore, significant differences in tape condition were found for only three variables with very small effect sizes, suggesting Kinesio® tape does not affect static postural control. This data agrees with previous research on effects of Kinesio® tape on dynamic postural control. Future research may investigate alternate taping techniques that may improve balance deficits in FAI.

Effects Of Kinesio Tape On Quadriceps Function In Patients With A History Of Knee Joint Injuries

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Context: Quadriceps dysfunction commonly persists in people with a history of knee injury or surgery. Modalities such as ice, heat, transcutaneous electrical nerve stimulation, and joint mobilization have been shown to improve quadriceps dysfunction by removing the underlying cause, arthrogenic muscle inhibition. Kinesio Tape (KT) has been used clinically in this patient population however the neurophysiologic rationale for its use is lacking. **Objective:** To compare quadriceps function in patients with a history of knee joint injury, and evidence of quadriceps arthrogenic muscle inhibition, after application of KT. **Design**: Randomized controlled, single blinded study. **Setting**: Laboratory. **Patients or Other Participants**: Sixteen subjects with a documented history of knee injury or surgery and quadriceps central activation ratio (CAR) less than 90% participated. Subjects were randomly allocated to either KT (7 males, 1 female; age=25±5.0 years; height =178.1±7.5cm; mass=78.9±14.1kg) or sham group (2 males, 6 females; age=23±3.5 years; height =175.3± 11.7cm; mass=74.6±16.0kg). **Interventions**: The KT group received a taping treatment using elastic KT covering from anterior inferior iliac spine to patella with approximately 75% of elastic tension in the mid line of the thigh. The sham group received a sham taping treatment using a non-elastic tape (Cover-Roll). Subjects remained in the lab for 2 post-treatment measures and returned 24-48 hrs later for follow up measures. Subjects wore their taping intervention for the duration of the study. **Main Outcome Measures**: A blinded assessor obtained H_{max}:M_{max} ratios for the quadriceps at baseline, immediately following treatment, 20 minutes following treatment and at 24-48 hours following treatment. Knee extension torque and CAR were measured during a knee extension maximal voluntary isometric contraction (MVIC) at baseline and after 24-48 hours. CAR was measured as the ratio between MVIC and the peak torque generated by an electrical stimulation delivered to the thigh superimposed during the MVIC test. A 2X4 ANOVA was used for H_{max}:M_{max} and a 2X2 ANOVA was used for knee extension torque and CAR. **Results**: There was no significant interactions for quadriceps H_{max}:M_{max} ($F_{3,42}$= 1.94,P =0.14). The ratios did not change over time ($F_{3,42}$ =0.52,P=0.67) and were not different between groups ($F_{1,14}$= 0.55,P=0.47). There were no interactions for knee extension torque ($F_{1,14}$=0.007,P=0.93) or quadriceps CAR ($F_{1,14}$= 0.03, P=0.86). Neither knee extension torque nor quadriceps CAR were different over time (Torque: $F_{1,14}$=0.004,P=0.95, CAR: $F_{1,14}$= 0.92,P=0.35) or between groups (Torque: $F_{1,14}$=0.25,P=0.63, CAR: $F_{1,14}$=0.39,P=0.54). **Conclusions**: KT did not change quadriceps neurophysiologic function immediately after or after a short period of time in patients with history of knee injuries and with evidence of quadriceps dysfunction.

Kinesiology Taping Does Not Improve Shoulder Proprioception, Shoulder Strength, Or Scapular Kinematics In Healthy Or Shoulder Impingement Subjects: A Preliminary Report

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Context: Kinesiology tape (KT) use in the clinical setting is growing; however, little evidence-based research exists to support/refute its use. KT has been asserted to reduce pain, alter muscle activation, enhance proprioception, and promote posturalalignment, which may be crucial when treating patients with subacromial impingement syndrome (SIS). **Objective:** To determine the effect of KT on shoulder proprioceptionstrength, and scapular kinematics (SK) in healthy and SIS subjects. **Design:** Placebocontrolled quasi-experimental study. **Setting:** Research laboratory. **Participants:** Data were collected on 10 healthy, physically active (age=25.78±3.78 years, height=1.69±0.09 m, mass=67.18±14.25 kg) and 9 physically active SIS participants (age=26.39±4.20 years, height =1.73±0.10 m, mass=77.52±14.87 kg). Control subjects had no history of musculoskeletal shoulder pathology; SIS subjects were diagnosed by a healthcare professional and presented with clinical signs of impingement. **Interventions:** Tests were performed on the dominant side (arm used to maximally throw a ball) for controls and impinged side for SIS subjects. All control subjects (n=10) received KT and SIS subjects were randomized to receive KT (n=5) or sham taping (ST,

n=4). Taping was performed by a certified kinesiology tape practitioner using the method recommended by the certifying organization. Participants were tested pre- and post-application. Threshold to detect passive motion (TTDPM) was assessed using an isokinetic dynamometer (passive mode, 0.25°/s) for shoulder internal/external rotation (IR/ER, 3 repetitions each). Path of motion replication (POMR) and SK were assessed using a 3D motion analysis system and custom guide (POMR: D2 proprioceptive neuromuscular facilitation pattern, 3 repetitions each; SK: scaption, 5 repetitions humeral elevation/depression). Isokinetic shoulder IR/ER strength was assessed using an isokinetic dynamometer (60°/s, 5 repetitions each). Post-test/pre-test differences were calculated. Data were analyzed by group using one-sample Wilcoxon Signed Rank Tests. Mann-Whitney U tests were used to assess differences between groups (Controls vs. KT, KT vs. ST). Statistical significance was set at $p<0.05$ *a priori*. Bonferonni corrections were applied to each variable category. **Main Outcome Measures:** Mean absolute error and root mean squared error in degrees were calculated for TTDPM (IR/ER) and POMR (3D humeral position), respectively. Scapular positions were extracted at 90° and 120° of humeral elevation/depression. Average peak torque was normalized to body weight (%BW) for shoulder IR/ER. **Results:** No significant differences were demonstrated in TTDPM (p-range:0.273-0.893), POMR (prange: 0.028-0.799), strength (p-range:0.225-1.000), or SK (p-range:0.043-1.000) when analyzed by group. No significant differences were demonstrated between groups in TTDPM (p-range:0.190-0.733), POMR (05range:0.0.142-1.000), strength (prange: 0.286-0.95), or SK (p-range:0.071-1.000). **Conclusions:** Preliminary findings indicate that taping does not appear to aid/impair shoulder proprioception, strength, or SK. Future research should explore if similar results can be replicated with larger sample sizes and in other pathological groups. Supported by Freddie H. Fu, MD Graduate Research Award and University of Pittsburgh, School of Health and Rehabilitation Sciences Research Development Fund

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Kinesio Tape For The Lower Leg Shifts Lateral Plantar Forces During Gait

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Context: Kinesio taping (KT) has become widely used in sports medicine over recent years for various pathologies. Mechanical support and increased proprioception are proposed benefits, but little evidence exists as to the efficacy of KT. Previous research suggests that KT changes timing of plantar forces among patients with a history of medial tibial stress syndrome (MTSS). It is unclear how KT may affect the magnitude of these plantar forces. **Objective:** To examine effects of lower leg KT on plantar forces in healthy subjects and subjects with a history of MTSS. **Design:** Pre-test post-test with control group. **Setting:** Biomechanics laboratory. **Patients or Other Participants:** Forty physically active subjects (20 male, 20 female) volunteered for this study. Twenty subjects had no history of exercise-related leg pain and twenty subjects had a history of MTSS. **Interventions:** Subjects were asked to walk barefoot across a pressure mat system prior to tape application (PRE), immediately following application of KT to the lower leg (KT-I), and 24-hours after KT use (KT-24). Tape was applied directly to the skin from the superior third of the medial tibia to the arch of the foot at 75% tension. Five trials were collected for each condition to ensure a reliable recording. **Main Outcome Measures:** Each trial was partitioned so the foot was divided into six areas: medial forefoot (MFF), medial midfoot (MMF), medial rearfoot (MRF), lateral forefoot (LFF), lateral midfoot (LMF), and lateral rearfoot (LRF). The dependent variable was normalized peak force (N/kgbw). A 3-way repeated-measures ANOVA was used to determine if

differences existed across tape conditions, foot areas, and groups. **Results:** A significant interaction effect of condition, area, and group was observed for peak force ($F_{10,380}=2.788$, $p=0.002$). Pairwise comparisons revealed that KT lowered peak forces in the LFF (PRE=1.12±0.28 N/kgbw, KT-I=1.01±0.20 N/kgbw, KT-24= 1.02±0.23 N/kgbw, $p<0.02$) and LMF (PRE=0.35±0.27 N/kgbw, KT-I=0.29±0.26 N/kgbw, KT-24= 0.31±0.28 N/kgbw, $p<0.03$) in healthy controls, but not MTSS subjects (LFF: PRE=0.98±0.30 N/kgbw, KT-I=1.01±0.31 N/kgbw, KT-24= 1.03±0.40 N/kgbw, $p>0.05$; LMF: PRE=0.27±0.24 N/kgbw, KT-I= 0.29±0.24 N/kgbw, KT-24=0.31±0.28 N/kgbw). KT also increased LRF peak forces from PRE (Healthy=0.95±0.14 N/kgbw, MTSS=0.86±0.15 N/kgbw) to KT-I (Healthy=1.01±0.19 N/kgbw, MTSS=0.95±0.26 N/kgbw)in both groups ($p<0.05$). **Conclusions:** Our results suggest that the use of KT on the lower leg may increase the lateral forces in the rearfoot in healthy and MTSS subjects, potentially due to initial contact occurring in a more supinated position. However, we observe that forces in the midfoot and forefoot are decreased, suggesting a beneficial role of the tape. While limited effects of KT were observed in the MTSS group, there were no baseline differences in plantar forces observed in our subset of patients, in contrast to previous studies.

Gender-Specific Biomechanical Profiles For The Development Of Patellofemoral Pain

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Context: Females are reported to have a two times greater risk of developing patellofemoral pain (PFP) as compared to males. In order to better understand this gender discrepancy in the risk of developing PFP, it is imperative that researchers investigate the risk factors for PFP that are specific to males and females. **Objective:** To prospectively compare lower extremity kinematics, strength, Q-angle, and navicular drop between those who developed PFP and those who did not develop PFP in a cohort of males and females. **Design:** Cohort. **Setting:** US Service Academies. **Patients or Other Participants:** The cohort consisted of 4019 participants (1455 females: age=18.6±0.8yrs, height =165.7 ±6.5cm, mass=62.9±7.9kg; 2470 males: age=18.9±0.9, height =177.86±6.9cm, mass= 77.25± 12.0kg) who were freshmen at the time of enrollment in the current investigation. **Interventions:** Each participant underwent a baseline biomechanical assessment including three-dimensional motion analysis during three trials of a jump-landing task, assessment of peak and mean isometric strength of thigh and hip musculature (two trials), and measurement of Q-angle and navicular drop (three trials). Following baseline data collection, participants were followed prospectively for a maximum of 4 years to identify those diagnosed with PFP. Incident PFP was determined by a manual review of medical records by the principal investigator. **Main Outcome Measures:** Sagittal, frontal, and transverse plane hip and knee kinematics during the jump-landing task at initial contact (IC) and 50% of stance phase (50%), mean and peak isometric strength [normalized to body weight (%BW)] of the knee flexors, knee extensors, hip extensors, hip abductors, hip internal rotators, and hip external rotators, Q-angle, and navicular drop were included in the data analysis. Separate one-way analyses of variance were performed to compare each dependent variable between individuals who developed PFP during the follow up period and those who did not develop PFP for males and females, separately (P<0.05). **Results:** 188 participants (94 females, 94 males) were diagnosed with PFP during the follow-up period. In males, the PFP group displayed less knee flexion (16.9±7.5° vs. 20.2±7.9°; P=0.01) and greater hip external rotation (-5.5±7.6° vs. -3.2 ±0.04°; P=0.01) at IC, greater hip abduction mean (0.35±0.09%BW vs. 0.33± 0.08% BW; P=0.03) and peak (0.42± 0.09%BW vs. 0.39±0.09%BW; P= 0.02) strength, and greater navicular drop (8.2±3.5mm vs. 7.5±2.8mm; P=0.02) compared to males who did not develop PFP. In females, the PFP group displayed less knee external rotation at IC (-1.8±7.3° vs. -3.8± 7.5°; P=0.02), greater knee internal rotation at 50% (3.8±9.7° vs. 1.5±9.7°; P=0.04), greater hip extension peak strength (0.30 ±0.08%BW vs. 0.27±0.08%BW; P=0.01), and less hip abduction mean strength (0.28±0.07%BW vs. 0.30± 0.08% BW; P=0.04) compared to females who did not develop PFP. **Conclusions:** Biomechanical risk factor profiles for PFP appear to differ between males and females. These findings may be used to develop effective PFP injury prevention programs specific to gender. *(Funded by R01-AR050461001 and R03-AR057489-01A1)*

Altered Hip Adductor – Gluteus Medius Activation Differences And Knee Valgus In Those With Patellofemoral Pain

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Context: Gluteus medius (GMed) weakness in patients with patellofemoral pain (PFP) has been observed previously. However, there is limited evidence of neuromuscular and kinematic alterations related to GMed function. Furthermore, it is unknown whether the muscular imbalance between the hip adductor (HA) group and the lateral hip musculature exists, which may contribute to further kinematic deficits in those with PFP. **Objective:** Determine if there were differences in HA and GMed activation onset and knee kinematics between PFP and healthy participants. **Design:** Case-control. **Setting:** Research laboratory. **Patients or Other Participants:** Twenty PFP (13F/7M, 21.45±3.90years, 169.96±10.47cm, 71.30±14.50kg) and twenty healthy participants (13F/7M, 21.35± 3.76years, 172.21±9.24cm, 69.68± 9.78kg) volunteered. **Interventions:** Knee valgus/varus angles during stance phase of stair ambulation were obtained using 3-D motion analysis, in order to obtain the mean valgus angle during the first 30% of the stance phase. A positive value indicated knee valgus. Additionally, electro-myographic recordings of the HA and GMed were obtained to identify the differences in the activation onsets relative to footstrike. A negative value indicated that HA activated earlier than the GMed. **Main Outcome Measures:** Dependent variables included the HA-GMed activation difference (H-G) and the mean knee valgus angle, during stair ascent and descent, separately. Independent variables included group (PFP, Healthy) and limb (asymptomatic, symptomatic). For each DV during the two phases of stair ambulation, separate two-way (Group, Limb) ANOVA's were utilized for statistical analysis. Significance was set *a priori* at $P<0.05$. Effect sizes (Cohen's *d*) with 95% confidence intervals also were calculated. **Results:** A significant effect for limb was found for H-G during stair ascent ($F_{1,38}=4.193$, $P=0.048$, $d=0.34$ [95%CI=-0.29, 0.96]). The asymptomatic side had earlier activation of HA relative to GMed, compared to the symptomatic side (Symp=-155.02±134.13msec, Asymp=-211.16±188.04msec). A significant group difference was found for H-G during stair descent, indicating that the PFP group displayed earlier activation of HA relative to GMed, compared with the healthy group ($F_{1,38}=6.862$, $P=0.013$, $d=-0.61$ [-1.25, 0.02], PFP=-24.24 ±132.16msec, Healthy =50.42 ±104.49msec). For knee valgus during ascent, there was a significant group difference ($F_{1,38}=6.424$, $P=0.016$, $d=0.67$ [0.03, 1.31]). The PFP group displayed more knee valgus, compared to the healthy group (PFP= -0.12±6.23°, Healthy=-4.23±5.80°). A significant group difference was also found for knee valgus angle during descent. The PFP group displayed more knee valgus compared to the healthy group ($F_{1,38}=7.452$, $P=0.01$, $d=0.75$ [0.11, 1.39], PFP= 1.73 ±4.14°, Healthy=-1.035±3.01°). **Conclusion:** An imbalance between the medial and lateral thigh/hip musculature exists in those with PFP, which may lead to increased knee valgus during activity. The results support the previous literature on muscular and kinematic deficits in PFP patients, and may suggest that excessive or premature activation of HA may possibly cause inhibition of GMed. Reestablishing muscle balance in the lower extremity should be a continued focus in rehabilitation of PFP patients.

Differences In Pelvic And Trunk Kinematics Among Those With And Without Patellofemoral Pain

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Context: Patellofemoral pain (PFP) is the most common injury in running and jumping sports. Investigators have reported reduced hip and trunk strength and differences in hip and knee mechanics in those with PFP. However, no study has investigated pelvis and trunk mechanics in this population. **Objective:** To compare sagittal, frontal, and transverse plane pelvis and trunk mechanics in those with and without PFP. **Design:** Cross-sectional. **Setting:** Research laboratory. **Patients or Other Participants:** 31 controls (17 females, 14 males: age= 27.0 ±77.1years; mass=68.4±11.5kg; height=173.0±9.2cm) and 46 PFP patients (25 females, 21 males: age=29.0±7.1 years; mass= 75.5 ±20.4kg; height=171.3±17.8cm) volunteered to participate. PFP participants were assessed by an AT and met inclusion criteria based on Boling (2006). The control participants were free from lower extremity injury and had no history of PFP. All participants exercised regularly a minimum of 30 minutes at least 3 days/week. For the PFP participants the most painful knee was

tested, and this was matched to the controls. **Interventions:** The independent variables were sex (male, female) and group (PFP, Control). Three-dimensional kinematic data were collected at 200 Hz and ground reaction force data were collected at 1000 Hz while participants ran (3.5-4.5 m/s) wearing standard footwear. After several practice trials, 5 trials were recorded. **Main Outcome Measures:** The dependent variables were stance phase peak absolute joint angles of the pelvis (APT, drop/lift, rotation) and trunk (FTL, contra- and ipsilateral lean, right and left rotation). 2X2 ANOVAs were performed to identify differences between the independent variables (P<0.05) and post-hoc tests were performed with Tukey (P<0.0125). **Results:** There was a significant group x sex interactions for APT (P=0.020). Post-hoc comparisons indicated that females with PFP demonstrated significantly less (P<0.001) peak APT than female controls (PFP=3.7±6.0°, Control=13.5±6.9°) and male controls (10.9±6.7°, P=0.006). There was no significant difference (P=0.096) in peak APT between females and males (8.1±6.1°) with PFP. Main effects for sex were found for peak pelvic lift (males: 3.7±2.1°, females: 5.3±2.0°, P=0.003), FTL (males: 15.7±5.6°, females: 12.3± 5.9°, P=0.016) and peak right (males: 12.0±4.7°, females: 17.0±5.8°, P<0.001) and left (males: 10.7±4.4°, females: 13.9±6.0°, P=0.003) trunk rotation. There were no significant differences in other variables measured (P>0.05). **Conclusions:** Decreased APT in females with PFP, combined with decreased FTL, may shift the center of mass posteriorly. This would increase the knee extensor demand and patellar compression, making women more susceptible to PFP. This might also be a compensatory strategy resulting from PFP. Individuals with PFP do not exhibit compensatory lateral trunk lean or pelvic drop. Females in general demonstrate greater transverse plane motion at the trunk during running, potentially showing the importance of hip and trunk muscular training in females, possibly as a preventative measure for PFP. Funded by the NATA REF: 808OUT003R, Alberta Innovates: Health Solutions, Wisconsin Athletic Trainers' Association, and UW-Milwaukee College of Health Sciences.

Prospective Pain And Function Outcomes After 6-Weeks Of Rehabilitation For Patellofemoral Pain Syndrome

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Context: Therapeutic exercise is a common intervention for a frequently diagnosed knee injury, patellofemoral pain syndrome (PFPS). Recent results from our randomized controlled trial (RCT) study indicate 6-weeks of rehabilitation focused on strengthening knee or hip/core musculature are equally effective in reducing pain and increasing function in physically active individuals with PFPS. However, pain and functional outcomes after treatment remain unknown. **Objective:** To assess differences in pain and function post-rehabilitation (6-WK) compared to 6-months post-rehabilitation (6-MOS) in PFPS patients who experienced treatment success compared to those who did not. **Design:** Single-blind RCT multi-centered study. **Setting:** Four clinical research laboratories across North America. Patients or Other Participants: 202 PFPS patients, assessed by an AT and meeting inclusion criteria based on Boling et al. (2006), volunteered to participate (67 males, 135 females: age= 29.36±7.33 years, mass= 69.46±14.17 kg, height=170.86±9.48 cm). **Interventions:** PFPS patients were randomly assigned to a treatment protocol (knee vs. hip/core). Each patient visited an AT 3 times/week over 6-weeks for rehabilitation progression. After completion of the

treatment protocol, PFPS patients were asked to discontinue the exercises and report back to the laboratory in 6-months. **Main Outcome Measures:** Pain and function were measured at 6-WK and 6-MOS using a 10 cm visual analog scale (VAS) and the anterior knee pain scale (AKPS). Treatment success was defined a priori as a decrease in VAS by 3 cm and/or an increase in AKPS of 8 points (maximum points possible: 100). Differences in pain and function over time (6-WK, 6-MOS) and between groups (successful, unsuccessful) were assessed using two 2x2 repeated measures ANOVAs (*P*d"0.05). **Results:** Of the 202 patients, 141 reported successful outcomes and 105 provided 6-WK and 6-MOS VAS and/or AKPS data. Thirty-eight of the 202 patients were unsuccessful and 26 provided 6-WK and 6-MOS VAS and/or AKPS data. There were no differences in pain over time in patients reporting successful outcomes (6-WK: 2.12±2.09 cm, 6-MOS: 2.29±2.37 cm, $F_{1,129}$=21.55 , *P*=0.99, n=105) nor in patients reporting unsuccessful outcomes (6-WK: 4.42±2.43 cm, 6-MOS: 4.25±2.60 cm, $F_{1,129}$=21.55, *P*=0.99, n=26). There were also no differences in function over time in patients reporting successful outcomes (6-WK: 89.40±10.48, 6-MOS: 88.59±11.07, $F_{1,118}$=18.35, *P*=0.72, n=98) nor in patients reporting unsuccessful outcomes (6-WK: 78.68±9.93, 6-MOS: 78.91±10.51, $F_{1,118}$=18.35, *P*=0.72, n=22). Regardless of time, the successful group had lower VAS (2.19±2.23 cm, *P*=0.00) and higher AKPS scores (89.06±10.76, *P*=0.00) compared to the unsuccessful group (4.34±2.49 cm, 79.22±10.39). **Conclusions:** At 6-months post-treatment, patients experienced no increases in pain or decreases in function regardless of whether reporting successful or unsuccessful outcomes at 6-weeks post-treatment. Therapeutic exercise focused on knee or hip/core strength appears to be an appropriate intervention for physically active PFPS patients. Funded by the NATA REF: 808OUT003R and Alberta Innovates: Health Solutions.

Kinematic Risk Factors For Lower-Extremity Stress Fracture Injuries

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Context: Stress fracture injuries disproportionately affect athletes and military service members and little is known about the modifiable biomechanical risk factors associated with these injuries. **Objective:** The purpose of this study was to prospectively examine the association between biomechanical factors upon entry to military service and the subsequent incidence rate of lower-extremity stress fracture during follow-up. **Design:** Prospective cohort study. **Setting:** We analyzed data from the JUMP-ACL cohort, an existing prospective cohort of military cadets. **Patients or Participants:** All participants were college freshmen entering a U.S. Service Academy. There were 1895 participants available for analysis. Fifty-two participants reported a history of stress fracture at baseline and were excluded from further analysis leaving 1843 participants. **Interventions:** Detailed motion analysis was conducted at the initiation of each subject's military career. Kinematic data were collected from the subject's dominant leg during three jump-landing trials. A Flock of Birds® (Ascension Technologies, Inc., Burlington, VT) electromagnetic motion analysis system controlled by Motion Monitor® (Innovative Sports Training, Inc. Chicago, IL) data acquisition computer software was used to collect three-dimensional coordinates of selected anatomical landmarks at a sampling rate of 144 Hz. **Primary Outcome Measures:** The primary outcome of interest was the incidence rate of lower-extremity stress fracture during the follow-up period. The electronic medical records of each potential incident case were reviewed and each case was confirmed by an adjudication committee consisting of two sports medicine fellowship trained orthopaedic surgeons. The association between incident stress fracture and sagittal, frontal, and transverse plane hip and knee kinematics during the jump-landing task were examined at initial contact (IC), 15%(T15), 50%(T50), 85%(T85) and 100% (T100) of stance phase. We used univariate and multivariable Poisson regression models to analyze the data. **Results:** Overall, 94 (5.1%, 95%CI: 4.14, 6.21) subjects sustained an incident stress fracture during the follow-up period. Compared to those with greater than 5° of knee valgus, subjects with neutral or varus knee alignment exhibited incidence rates for stress fracture that were 43%-53% lower at IC (IRR=0.57, 95%CI: 0.29, 1.11, p=0.10), T50 (IRR=0.47, 95%CI=0.23, 1.00, p=0.05), and T85 (IRR=0.53, 95%CI: 0.29, 0.98, p=0.04). Subjects with greater than 5° of internal knee rotation exhibited rates for stress fracture that were 2-4 times higher at T15 (IRR=2.31, 95%CI: 1.01, 5.27, p=0.05), T50 (IRR=3.98, 95%CI: 0.99, 16.00, p=0.05), and T85 (IRR=2.31, 95%CI: 0.86, 6.23, p=0.10), when compared to those with neutral or external knee rotation. **Conclusions:** Knee valgus and internal rotation during a jump landing task at baseline appear to be associated with a 2-4 fold increase in the incidence rate of lower-extremity stress fracture injuries during follow-up. Future research should examine the role of injury prevention programs in decreasing stress fracture incidence by targeting high-risk movement patterns.

Optimal Rehabilitation Protocols for the Treatment of Patellofemoral Pain Syndrome: an Outcome-Based RCT Study

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Context: Patellofemoral pain syndrome (PFPS) is the most common injury in running and jumping sports. The gold standard for PFPS rehabilitation has traditionally been strengthening the muscles surrounding the knee (KNEE). More recently, it has been suggested the aetiology of PFPS is related to reduced hip and core strength (HIP). However, no randomized controlled trial (RCT) studies have determined the optimal rehabilitation for PFPS. **Objective:** To compare pain and function between KNEE and HIP rehabilitation protocols using an RCT approach. We hypothesized greater improvements in visual analog scale (VAS) and Anterior Knee Pain Scale (AKPS) scores for HIP as compared to KNEE. **Design:** Single-blind RCT multi-centered study. **Setting:** Four clinical research laboratories across North America. **Patients or Other Participants:** 202 PFPS patients, assessed by an AT and meeting inclusion criteria based on Boling et al. (2006), volunteered to participate (67 males, 135 females: age=29.36±7.33 years; mass= 69.46± 14.17kg; height= 170.86±9.48cm). **Interventions:** PFPS patients were randomly assigned to a treatment protocol: KNEE vs. HIP. Each subject visited an AT 3 times per week over a 6-week period for rehabilitation progression. **Main Outcome Measures:** VAS and AKPS were collected at baseline and one time per week over 6-weeks. Treatment success was a priori defined as a decrease in VAS by 3cm and/or an increase in AKPS of 8 points. Data were analyzed using an intent-to-treat basis. We calculated the mean change scores within groups, and differences in change scores between groups, with 95% confidence intervals (CI) and performed 2x2 ANOVAs (group x time; $P \leq 0.05$) on the VAS and AKPS scores. **Results:** At baseline, no differences ($F_{1,199}=0.92$; $P=0.54$) in VAS were observed between HIP (5.12±1.65cm; CI: 5.50-4.73cm) and KNEE (4.97±1.61cm; CI: 5.35-4.60cm) and no differences ($F_{1,199}=0.78$; $P=0.66$) in AKPS were observed between HIP (75.00±9.74; CI: 77.28-72.72) and KNEE (75.62±9.81; CI: 77.91-73.34). 23 patients dropped out after baseline testing, 141 PFPS reported a successful outcome, and 38 were unsuccessful. Of the 141 successful outcomes, 70 were HIP and 71 were KNEE and no differences in either VAS ($F_{1,138}=0.77$; $P=0.69$) or AKPS ($F_{1,138}=0.91$; $P=0.57$) were measured between groups. HIP exhibited an average decrease of 3.58±1.94cm in VAS (CI: 1.38-2.16) and 17.62±9.46 increase in AKPS (CI: 90.37-93.68) while KNEE demonstrated an average decrease of 3.65±1.74cm in VAS (CI: 1.19-1.79) and 18.91±12.69 increase in AKPS (CI: 90.69-93.79). **Conclusions:** With ATs as the primary interventionists, this RCT study demonstrated significant improvements in pain and function for one of the most common musculoskeletal injuries. Both KNEE and HIP protocols improved patient-centered outcome scores after 6-weeks of therapeutic strengthening. This is the first RCT study investigating KNEE vs. HIP protocols for patients with PFPS. Funded by the NATA REF: 808OUT003R and Alberta Innovates: Health Solutions.

Patient-Centered And Clinical Outcomes Associated With Grade II Lateral Ankle Sprains: A Case Series

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Background: The purpose of this case series is to describe the clinical and patient-centered outcomes of 5 collegiate athletes who presented to their respective athletic training facilities with grade II lateral ankle sprains. These patients (2 female, 3 male; age=19.4±0.8years) were participating in NCAA athletics (lacrosse, track, soccer and baseball) and sustained a lateral ankle sprain associated with an inversion mechanism while running or landing. Four patients reported no previous history of ankle sprain. All patients exhibited mild-to-moderate instability with manual stress tests (anterior drawer and talar tilt), point tenderness over the lateral ankle ligaments, limited ROM compared to the contralateral ankle, pain with weight-bearing, and sudden onset of edema within 72 hours of injury. All patients were monitored over the course of treatment using objective clinical measures (OCM) including pain, the global rating of change scale (GROC), and active dorsiflexion range of motion (DROM) along with self-reported measures of health including the Foot and Ankle Ability Measure (FAAM), the FAAM-Sport, the Cumberland Ankle Instability Tool (CAIT), and the Tampa Scale of Kinesiophobia-11 (TSK-11). While the FAAM, FAAM-Sport, and CAIT are patient reported outcomes (PRO) focusing on regional measures of health associated with the foot and ankle, the TSK-11 describes the fear of movement. **Treatment:** Treatment and rehabilitation protocols for each patient were dependent upon the discretion of their respective athletic trainer. Patients completed PRO and OCM one day post-injury (Day1), one week post-injury (Week1), and at return to play (RTP)(19.6±5.86days). Active DROM was measured in degrees with the patient in prone position with the knee extended. Pain was measured in centimeters using a visual analog scale (VAS) and changes in self-reported injury status were measured using the GROC. The FAAM contains 21 items related to activities of daily living (highest score=100%), the FAAM-Sport contains 8 items related to sport-specific activity (highest score=100%), and the CAIT contains nine items pertaining to instability during activity (highest score=30). All items on the FAAM, FAAM-Sport, and CAIT are graded on a Likert scale with higher scores indicating greater self-reported function. The TSK-11 is an 11-item questionnaire graded on a 4-point Likert scale (total=44, lowest=11) with higher scores indicating greater fear of movement. **Results:** All patients demonstrated improvements in OCM as indicated by changes in DROM (Day1=6.6±8.47°; Week1 =10.6±5.32°), pain on the VAS (Day1=5.28±2.41cm; Week1=1.5±1.19cm) andhe GROC (Day1=-0.02±2.0; Week1=2.8±0.83). The improvements in OCM corresponded to improvements in overall health status as indicated by changes in PRO measures for the FAAM (Day1= 55.50±20.00%; Week1=79.00±23.50%), the FAAM-Sport (Day1=11.87±3.56%; Week1 =27.50±6.38%), the CAIT (Day1 =8.20±7.43; Week1 =13.60 ±7.43) and the TSK-11 (Day1=26.80±3.27; Week1=22.20±3.03). The GROC continued to improve at RTP (4.5±0.55) while pain (0.06±0.09cm) and DROM (10.6±7.13°) did not change. Upon RTP, all patients demonstrated high levels of function on each PRO measure (FAAM =98.50±2.05%; FAAM-Sport= 96.25±5.59%; CAIT=24.60±3.21; TSK-11=16.00±2.34) indicating minimal functional loss. **Uniqueness:** There is a lack of evidence supporting the use of PRO and OCM to track the progress during rehabilitation of lateral ankle sprains. This case series demonstrates how patient-centered measures of function can be used to enhance patient evaluation and track rehabilitation progress when combined with traditional clinical indicators of function. **Conclusions:** Following lateral ankle sprain, patients demonstrated decreases in pain, increases in DROM, and improvements in perceived injury status which corresponded with improvements in self-reported measures of health assessed through PRO instruments. All patients demonstrated improvements in OCM and PRO at RTP regardless of their rehabilitation plan. However, PRO instruments continued to identify improvements at RTP despite a plateau in certain OCM. This demonstrates the benefit of combining OCM and PRO for tracking the rehabilitation progress for patients with lateral ankle sprains.

Treatment Characteristics And Estimated Direct Costs Of Care Provided By Athletic Trainers For Upper Extremity Disorders: A Report From The Athletic Training Practice-Based Research Network

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Context: Data regarding the treatment characteristics and estimated direct costs of care (DCC) for athletic training services (ATS) provided outside of the Centers for Medicare and Medicaid Services (CMS) system are limited. To appropriately value ATS occurring in traditional practice settings, it is important to describe the treatment characteristics and estimated DCC for ATS as if those **services were reimbursed by CMS. Objective:** Describe treatment characteristics and estimated DCC for ATS for upper extremity disorders (UED). **Design:** A retrospective analysis of electronic medical records. **Setting**: Athletic Training Practice-Based Research Network (AT-PBRN). **Patients or Other Participants:** Medical records of 951 patients (male=648, female=303, age= 17.1±2.0 yrs, height=171.7±12.0 cm, mass=71.7±16.1 kg) diagnosed with an UED by an athletic trainer (AT) within the AT-PBRN. **Interventions:** Medical records of patients who received ATS between October 2009-October 2012 from 65 clinical practice sites within the AT-PBRN were reviewed. All medical records were created by an AT utilizing a web-based electronic medical record (EMR). Each UED was defined as a unique case and identified utilizing UED-specific diagnostic codes (ICD-9). **Main Outcome Measures:** Summary statistics were calculated for patient and UED demographics. Treatment characteristics included duration of care [initial evaluation to last documented episode of care (EOC)], EOC's (number of documented patient encounters), type of ATS provided (CPT codes). DCC were estimated by applying the 2012 CMS Physician Fee Schedule (MPFS) national payment amount. The MPFS online database was utilized to determine the non-facility (i.e., non-hospital) price for each CPT code. Codes were priced in accordance with the number of units recordedand the DCC for each EOC were estimated. **Results:** The most frequent region ofupper extremity injury was the shoulder (43.4%) followed by the wrist (12.1%). Sprain/strain of hand/ finger (ICD9: 842.10) was the most frequent UED diagnosis overall (12.5%). Subluxation/dislocation (ICD9: 831.00) was the most common shoulderdiagnosis (14.5% of all shoulder injuries) and sprain/ strain (ICD9: 842.00) was the most common wrist diagnosis (53.0% of all wrist injuries). The most frequently utilized treatments were hot or cold pack [CPT 97010 (33.0%)], therapeutic exercise [CPT97110 (21.9%)], manual therapy [CPT 97140 (8.3%)], electrical stimulation [CPT 97032(6.8%)], and ultrasound [CPT 97035 (5.9%)]. The average duration of care was12.0±30.4 days and the average number of EOC's was 2.71±3.7 per UED. The average number of treatments provided per EOC was 1.94±1.01. The average total cost of carewas $188.34 ±316.67 per UED and the average cost per EOC was $67.52 ±33.30.**Conclusions:** These data provide important information about the treatmentcharacteristics and estimated DCC for ATS provided outside of the CMS system. Thesedata speak to the value of ATS and potential cost savings to the healthcare system when ATS are provided in a population-based practice model outside of CMS.

Changes In Athlete Self-Reported Symptomatology Over Time Following Sport-Related Concussion: Are We Overly Optimistic?

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Context: The decision to return an athlete to play following concussion relies, in large part, on athlete self-report of symptomatology. Current guidelines suggest that athletes should never return-to-play following concussion if they have ANY symptoms. **Objective:** To assess changes in high school athlete self-reported symptoms and health-related quality of life (HRQOL), following a concussion. **Design:** Cohort. **Setting:** High school athletic training facilities. **Patients or Other Participants:** A convenience sample of 147 adolescent athletes (118 males, 29 females, age=16.0±1.1; grade= 9.4±1.0) who suffered a sport-related concussion diagnosed by an athletic trainer. **Interventions:** The independent variable was time since concussion. Participants completed the Sport Concussion Assessment Tool-2 (SCAT2) symptom evaluation during a pre-season baseline (BL), at Day of Injury (D0), Day 3 (D3), Day 10 (D10) and Day 30 (D30) post-injury. Two measures of HRQOL, the Pediatric Quality of Life Inventory (PedsQL) and Multidimensional Fatigue Scale (MFS) were completed at BL, D3, D10 and D30. **Main Outcome Measures:** Dependent variables included scores from the SCAT2 symptom scale, PedsQL Total and MFS General Fatigue subscale. Two summary scores were calculated from the 22-item SCAT2 symptom scale: Total Symptom Score (TSS) and Total Symptoms Endorsed (TSE). Lower scores indicate lower symptom severity (TSS) and fewer endorsed symptoms (TSE). The PedsQL and MFS are valid and reliable measures of HRQOL in pediatric patients. Lower scores indicate lower HRQOL. A generalized estimating equations approach was used to assess change over time. Bonferroni-adjusted comparisons evaluated pairwise differences ($p<.05$, two-tailed). **Results:** 147 athletes completed the SCAT2 symptom evaluation at BL, D0, D3, D10 and D30. A subset of these athletes (n=121, 82%) completed the PedsQL and MFS at BL, D3, D10 and D30. The TSS and TSE both showed significant increases from BL (TSS: 9.5±12.5; TSE:4.4±4.8) at D0 (TSS: 27.2±20.6, TSE: 10.7±5.8 and D3 (TSS: 17.4±19.3, TSE: 7.5±6.5), $p<0.001$. Average scores for both returned to BL by D10, $p=1.0$. However, at D30, both were significantly lower (TSS: 2.6±4.5, TSE: 1.8±3.1) than BL, $p<0.001$. A similar pattern was noted for the PedsQL and MFS scales: Scores were lower at D3 than BL ($p<0.001$), but exceeded BL at D10 and D30, $p<0.001$. **Conclusions**: Athlete self-report of symptomatology must be considered in making a return-to-play decision; however, concussion management models may offer a perverse incentive; they may lead to unintended and undesirable consequences. Concussed athletes know they must be "symptom-free" to return-to-play. Our data suggest that athletes report significantly fewer and less severe symptoms at D30 than at BL. Likewise, by D10, their HRQOL significantly exceeds BL. We suspect that concussion does not decrease symptomatology or increase HRQOL from baseline measures a few days post-concussion. Alternatively, self-report of both may be overly optimistic and driven by the desire to return-to-play.

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The Relationship Between The Time In Each Step Within A Return To Play Guideline For Sports-Related Concussion Among High School Student-Athletes

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Context: Assessment and management in sport related concussion has been studied from various aspects. Current research demonstrated the importance of creating a return to play guideline for concussed athletes to return to play in the safest manner. **Objective**: To investigate the relationship between the numbers of days from concussion onset to full return to sports participation using the State of Hawaii return to play (RTP) protocol among high school student-athletes. **Design**: Retrospective case review of concussions reported between 2010 and 2012. **Setting**: The State of Hawaii has implemented a comprehensive RTP protocol that tracks step wise cognitive rest periods and physical exertion periods of concussion recovery. Certified athletic trainers from 64 high schools in the State of Hawaii participated in the Concussion Management Program. They were instructed to complete a concussion log for each concussed athlete. **Participants**: De-identified data from 375 were concussions accurately reported with patients completing the RTP protocol during 2010-2012. 229 male (mean age ± SD = 15.56 ± 1.18) and 138 females (mean age ± SD = 15.29 ± 1.16) were included. **Interventions**: The completion date of each step was recorded as follows: Step 1 = cognitive rest, Step 2 = return to

school full time, Step 3 = Light exercise, Step 4 = Running, Step 5 = Non-contact drills, Step 6 = Full contact practice, and Step 7 = no restrictions. Each step was separated by at least a 24 hour period. **Main Outcome Measures**: Correlation analysis and multiple regression analysis were conducted to analyze the relationship among the steps in the protocol. Days between each step and the total days each concussed athlete spent to complete the protocol served as the primary outcome measures. **Results**: Days between Step 2 and 3 had the strongest correlation with the total days missed in the protocol ($p < 0.01$, $r = 0.84$). With multiple regression analysis, the time between Step 2 and 3 remained significant predictor of the total days missed (R square = 0.70). **Conclusions**: 70% of the total days missed in the protocol were accounted for the days between Step 2 and 3. In other words, the longer the concussed athlete took to complete the light exercise phase without any reoccurring symptoms, the more severe the concussion was. Possible reasons for the concussed athletes whose Step 2 to 3 were prolonged might be due to two reasons: Their cognitive rest period was too short, and no formal school accommodations plans administered. Future studies should investigate the symptoms and neurocognitive scores reported during each step of the RTP protocol. Also, the effect of implementing school accommodations to recover from concussion should be investigated.

Return To Play Progression Following Concussion Using Standardized Exercise And Intensity

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Background: This case series follows nine high school football players through a return to play progression following a concussion. The athletes' average age was 16.22 years and average grade in school was 10.89, average height and weight were 70.97 inches and 201.11 pounds respectively. Six athletes were followed after their first documented concussion. Three had at least one previous concussive injury with the most recent for each occurring during the previous football season. Six injuries occurred in practice and three during game play. All athletes were evaluated by an athletic trainer or physician within 24 hours and determined to have sustained a concussion. **Treatment:** The athletes participated in a six phase return to play progression where phase one consisted of rest, resolution of symptoms, a full day of school without the return of symptoms and neurocognitive testing showing recovery. Phases two through four consisted of exercise controlled for activity and intensity level. Exercise intensity was monitored using the Borg Rating of Perceived Exertion Scale (RPE) and/or heart rate monitoring. Criterion for progression to each new step of these phases was remaining asymptomatic before, during and after exercise, monitored with a graded symptom checklist, and at least 24 hours between steps. In phase two of the program, athletes completed 15 minutes of stationary cycling at an intensity of 8 to 11 on the RPE scale. In phase three, athletes completed four exercise circuits alternating cardiovascular stress with upper body, lower body, core, and balance activity. Tasks were changed every 30 to 60 seconds, depending on fitness level and exertion, and a two minute rest was given between each circuit. Exercise intensity for phase three was kept between 11 and 14 on the RPE scale. Phase four also used four exercise circuits with the addition of change of direction and plyometric tasks to the components of the phase three circuits. Exercise intensity for phase four fell between 14 and 18 on the RPE scale. Phase four also included non-contact sports specific drills as part of practice following completion of the exercise circuits. Phase five consisted of a full-contact practice and phase six entailed participation in a game. **Results:** The average amount of time for return to play for athletes without previous concussion was 22 days (range 15 to 29). For those with previous history of concussion this was 21.33 days (range 17 to 23). Overall the time elapsed between the concussion incident and initiation of exercise was on average 11.67 days (range 5 to 16). For the athletes with previous concussion this was 13.33 days (range 8 to 16), and for those without history of concussion this was 10.83 days (range 5 to14). For athletes without history of concussion phases two, three, four, and five occurred at 10.83, 14, 16.5, and 18.17 days respectively. For the athletes with previous history of concussion those averages were 13.33, 15, 17, and 18.67 days respectively. Average time elapsed between the initiation of exercise and full return to game play for all athletes was 10.78 days (range 7 to 16). For athletes without previous concussion this was 11.17 days (range 7 to 16) and 10 days (range 8 to13) for those with a previous concussion history. **Uniqueness:** This case is unique in that exercise and intensity were controlled and standardized using the RPE scale and/or heart rate monitoring during each phase of the return to play progression.

Conclusions: Certified Athletic Trainers were able to successfully return multiple athletes to high school football utilizing a return to play progression that controlled for both exercise type and level of exertion throughout the return to play process.

Self-Reported Concussion Management Practices Among Secondary School Athletic Trainers

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Context: The evaluation of sport-related concussion by athletic trainers (AT) is essential in ensuring proper management and safely returning an athlete to play. Current recommendations suggest a written policy and multifaceted approach to assessment and management constitute best practices, however it is unclear how secondary school ATs are practicing. **Objective:** To describe the concussion management practices among secondary school ATs. **Design:** Cross-sectional design. **Setting:** Self-reported online survey. **Patients or Other Participants:** 851 clinicians (25.9% response rate) from a convenience sample of ATs that were currently practicing in the secondary school setting (308 males, 376 females, 167 missing, age= 37.9 ±22.3). **Interventions**: Participants were solicited via email to complete the *Athletic Trainers' Beliefs, Attitudes, and Knowledge of Pediatric Athletes with Concussions (BAKPAC-AT)* survey. The BAKPAC-AT consisted of several multipart questions to assess ATs' current concussion management practices regarding policy, standing orders, baseline and follow-up testing and clearing athletes to return-to-play. **Main Outcome Measures:** The dependent variables were participants' responses to the concussion management questions. Descriptive statics were used to evaluate the use and types of baseline and follow up assessment tools. Separate forward stepwise binary logistic regression analyses ($p<.05$) were used to determine whether any personal (years certified, experience in secondary school setting) or school (enrollment, type, presence of football) demographic predicted the use of baseline or follow-up assessments and whether the AT clears athletes to return-to-play. **Results:** The majority of ATs indicated they had a written concussion policy (82.4%, n=701) and standing orders approved by their directing physician (67.3%, n=573). Baseline testing was used by 75.1% (n=639), with the majority using computerized neurocognitive tests (71.2%, n=606) and fewer using balance assessments (9.2%, n=78) and a symptom scale (11.4%, n=97). Follow-up concussion testing was employed by 81.8% (n=696) with computerized neurocognitive testing being employed by 68.5% (n=583), balance testing by 23.5% (n=200), symptom scales by 35.5% (n=302) and sideline assessments (eg. SCAT2) by 40.5% (n=345). Approximately 70% (n=603) of ATs indicated they clear athletes following return-to-play protocols. The regression analyses found that years of certification ($p=.049$) and type of secondary school ($p=.033$) predicted the use of baseline testing with ATs practicing 3-5 years more likely to baseline test compared to those practicing less than 2 years and public charter school affiliation more likely to test than public schools. There were no significant predictors of follow-up testing. **Conclusions:** Most ATs surveyed were engaged in management protocol involving baseline and follow-up testing. In both instances, neurocognitive testing was most often utilized. Ideally, a multifaceted approach that also includes balance testing and symptom assessment should all be administered at baseline and follow-up. Demographic information regarding years certified and location of practice can aid educational efforts to ensure all ATs are using best practices in concussion management.

Comparison Of Concussion Management Programs On Return To Participation Outcomes Of Concussed High School Student-Athletes During 2011-12

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Context: A multifaceted approach for the management of sport-related concussion that includes a clinical examination, graded symptom check list, postural stability testing, neurocognitive testing, and a Gradual Return to Play Protocol (GRPP) has been recommended by several concussion consensus statements and position papers. Healthcare professionals caring for concussed student-athletes across the United States may not be following these guidelines and therefore allowing student-athletes to return to participation (RTP) prematurely. **Objective**: To investigate how the duration of RTP and GRPP for concussed high school student-athletes was influenced by the type of Concussion Management Program (CMP), which incorporated two different neuropsychological testing batteries for RTP decision-making. **Design**: Retrospective cross-sectional investigation. **Setting**: Two different neurocognitive tests were utilized within the CMP of 37 public high schools and 3 private high schools in the State of Hawaii. **Patients or Other Participants**: Concussed student-athletes (*n*=390, between the ages of 13 to 18) received baseline and post-concussion neurocognitive testing during school year (SY) 2011-12. **Interventions**: Two different neurocognitive tests used in a CMP were compared: 19 schools utilized the Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT) and 21 schools utilized Standard Assessment of Concussion (SAC). **Main Outcome Measures**: The difference in means between two different neurocognitive tests used in the CMP (ImPACT *n*=225, SAC *n*=165) were compared using an independent samples t-test. Days of restricted participation post-concussion and duration of the GRPP until return to unrestricted participation, mean, standard deviation (SD), and 95% confidence intervals (CI) were reported. The duration of the GRPP was defined as the number of days of the rehabilitation period, starting from light aerobic exercise to full-contact practice. The GRPP consisted of five steps, each separated by a minimum of 24 hours. **Results**: A significant (F1=2.865, *p*=.033) difference was found between restricted participation post-concussion for ImPACT=26.25±18.99 (CI= 23.76 – 28.75) days compared to SAC=22.50±14.17 (CI= 20.32 – 24.67) days. No significant (F1=.728, *p*=.870) difference was found for the average duration of the GRPP incorporating ImPACT=10.30±7.06 (CI=9.38 – 11.25) days compared to SAC=10.18±7.37 (CI=9.05 – 11.31) days. **Conclusions**: The duration of GRPP for concussed student-athletes was not significantly different; however, the days of restricted participation post-concussion was significantly different when using the two different neurocognitive testing batteries (SAC or ImPACT) within the CMPs. The schools that utilized ImPACT in the CMP had a significantly longer number of days restricted than the schools that utilized SAC in the CMP. This result indicates a more conservative approach to RTP decision-making by Athletic Trainers who utilized the CMP incorporating ImPACT. The two testing batteries used in this study are just one part of the multifaceted nature of RTP decision-making within a comprehensive CMP. Thus, utilizing additional clinical examinations is vital to prevent the premature release of concussed student-athletes.

Concussion Management Protocols In The Military And The Role Of The Athletic Trainer: A Systematic Review

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Context: Athletic trainers are on the forefront of managing mild traumatic brain injury or concussions in the physically active population. However, in the various military settings, other health care professionals tend to fill the role of concussion management. Incidence rates are increasing in theaters (combat) such as Operation Iraqi Freedom and Operation Enduring Freedom largely due to increased symptom awareness and increased use of improvised explosive devices. Many of the concussion management protocols in the military have been developed from sport-related concussion research, with one difference being the small number of athletic trainers working with soldiers in garrison (domestic base). **Objective:** To critically analyze the concussion management protocols of the military and determine the potential role athletic trainers could fulfill while working in this emerging practice setting. **Data Sources:** A computerized search for relevant articles was performed using the databases PubMed, Military and Government Collection, SPORT Discus, and Health Source: Nursing/ Academic edition from 2000-2012. The search was conducted using the keywords: concussion management and military, sport concussion epidemiology, sport-related concussion, and WARCAT. Limits were: published in peer reviewed journals, full text available, English, and humans. **Study Selection:** Articles were selected by reading the abstract, scanning headings and titles for relevance to concussion injuries in the military, sport-related concussion, management protocols, duties of healthcare professionals and athletic trainers. **Data Extraction:** Full-text of 22 articles was reviewed, we summarized major findings in a spreadsheet and scored each article on the Strength of Recommendation Taxonomy (SORT) or if the article contained human subjects we scored it using the Physiotherapy Evidence Database (PEDro) scale. **Data Synthesis:** Data were synthesized by categorizing the SORT levels of evidence and summing the frequency of each level of evidence (1 through 3). We found that 86.4% (19/22) of the articles were not human subjects and were scored as SORT Levels of Evidence 3 and 13.6% (3/22) were scored 2. For the 22.7% (5/22) of articles that included human subjects, the PEDro score was 5±0 points. **Conclusions:** The military recognizes the importance of concussion management and implements current research into their management protocols. The Military Acute Concussion Evaluation was adapted from the Standardized Assessment of Concussions and is used to diagnose and help guide a safe return to duty. Neuropsychological batteries such as ImPACT have been validated and implemented in garrison and in theater. As opposed to in garrison, concussion management in theater is complicated by access to medical resources, remote locations, and duration of missions. Athletic trainers' understanding of concussion management and coordination with military personnel may positively impact the soldier's standard of care upon return from theater. Concussion management in garrison needs continued investigation and development which may be where athletic trainers can make the greatest contribution.

An Investigation Of Concussion Education Content And Effectiveness

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Context: Since 2009, both Washington and Idaho have enacted concussion laws requiring formal education of athletes and coaches. Our primary focus was to determine the effectiveness of *currently provided* education methods regarding concussion knowledge within Washington and Idaho high schools (9^{th} -12^{th} grade). **Objective**: The proposed project is designed to identify and assess effectiveness of the variety of concussion education instructional delivery methods currently used. **Design**: The study used content analysis to understand existing education methods, including comparisons between the content of the various identified methods. A pre-survey was administered to both coaches and student athletes prior to dissemination of the *current concussion* education program utilized by each school. Following the athletic season a post-survey was conducted to assess retention of knowledge. **Setting**: Surveys were administered in a classroom or gymnasium location during both the pre-education survey and post-season survey. **Patients or Other Participants**: Participants were high school football and girls' soccer athletes and coaches from Washington and Idaho. The schools were selected based on proximity to the area, availability of an athletic trainer at the location and various alumni connections. Fourteen high schools participated, including 14 football programs and 6 soccer teams. **Interventions**: Surveys were administered in a paper and pencil format by an athletic trainer or coach. The survey was based on a combination of multiple existing surveys regarding concussion knowledge. The survey

was used to examine the *currently provided* program from each school. **Main Outcome Measures**: There were several outcomes in this study including (a) identify concussion education methods utilized to meet requirements of the concussion laws, (b) detail current curriculum and conduct a literature search to determine optimal instructional delivery, (c) statistically compare the impact of methods of education, and (d) disseminate information concerning optimal concussion education interventions and methods. **Results**: The content analysis is on-going as fall sports seasons are concluding. Initial results of pre-season surveys demonstrate that student athletes still struggle with basic concussion application questions. Most students answered incorrectly that LOC must occur for a concussion to be present. Athletes also struggled to answer correctly when an athlete should be removed from play, or allowed to return based on initial symptoms. This survey was *before* the education program was administered, so results will need to be compared to post education surveys. Once the content analysis is complete comparing pre and post season surveys, results will determine areas of weakness in *currently* delivered concussion knowledge among coaches and student athletes. **Conclusions**: Through assessing effectiveness of *current concussion* education programs in Washington and Idaho, awareness of gaps in knowledge and delivery methods is exposed. Results allow for development of an effective concussion education model to be established and promoted statewide .

A Content Analysis Of Trends In State Sport Concussion Management Legislation

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Context: Since 2009, 40 states have passed sport-concussion management (SCM) legislation. With the exception of NFL influence, most statutes reflect the nuances of local state politics. Therefore, little is known about the collective management trends emerging from these initiatives, nor is there a complete understanding of the impact of these statutes on athletic training (AT) practice. Objective: To identify the components of state SCM legislation and the frequency with which they are implemented. Design: A descriptive, content analytic study. **Setting:** Text of approved state SCM statutes. **Patients or Other Participants:** The text of all enacted state SCM statutes was secured from state legislative websites. When necessary, secondary policy documents created by other stated agencies and referred to by SCM statutes were secured. **Data Collection and Analysis:** All texts were subjected to an inductive content analytic process based on an established coding scheme. This produced 39 variables in six clusters representing key statutory components: 1) descriptives, 2) education, 3) patient management, 4) provider decision-making authority, 5) return-to-play (RTP) procedures, and 6) liability protections. The lead author completed all coding, following a coding scheme approved by an expert panel, which also resolved coding problems. **Results:** Descriptives: Thirty-nine states and D.C. (n=40; 78.4%) passed SCM statutes; five (9.8%) are pending; 6(11.8%) have none. Education variable cluster: All (n=40; 100%) require distribution of concussion education, but only 24(47.1%) require focused training for coaches; surprisingly, 8(15.7%) states mandate AT training and 4(7.8%) physician training. Thirty-four (62.7%) require signed informed consent before participation. Patient management cluster: All (n=40; 100%) require removal from play if concussion is suspected, but only 14(27.5%) prohibit same-day return; no states require baseline neurocognitive testing, but 2(3.9%) require it post-injury. Provider decision-making authority cluster: All (n=40; 100%) require clearance before RTP, and 9(17.6%) restrict clearance authority to physicians; 17(33.3%) give clearance authority to undefined "licensed health care providers", while 28(54.9%) require the provider to have "training in concussion evaluation and management"; the most commonly authorized providers are physicians (n=40; 100%), ATs and physician assistants (n=11; 21.6%), nurse practitioners (n=10; 19.6%) and neuropsychologists (n =7; 13.7%). Return to play cluster: Only 5(9.8%) and 8(15.7%) mention, but do not mandate, academic accommodation or graduated return-to-activity, respectively. Liability protections cluster: 8(15.7%) provide immunity to schools, 7(13.7%) to school employees, and 9 (17.6%) to volunteer providers. **Conclusions:** This study reveals the rapidly emerging policy trends in SCM. It finds an inconsistent, and sometimes inefficient, national legal framework. It also demonstrates a contradictory legal standing for ATs who are frequently authorized to make clearance decision, but who are sometimes required to receive remedial concussion education and training. Future research must incorporate regulatory and scope of practice analysis to more accurately account for provider clearance authorization.

A Comparison Of Self-Reported Disability And Dynamic Postural Control Between Patients With Chronic Ankle Instability, Ankle Copers, And Healthy Controls

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Context: Diminished dynamic postural control assessed by the star excursion balance test (SEBT) and decreased self-reported function assessed by the Foot and Ankle Ability Measure (FAAM) and FAAM-sport has been demonstrated in individuals with chronic ankle instability (CAI) compared to healthy controls. However, limited comparisons have been made between CAI patients and ankle sprain copers who have sprained their ankles but did not develop CAI. Additionally, it is unclear if there is a correlation between the SEBT and FAAM measures. Understanding the differences between these measures among these groups may provide insight into the consequence and interventions for CAI. Objective: To compare SEBT performance, and self-reported disability among individuals with CAI, copers, and healthy controls; and to determine if there is a correlation between the selected outcome measures. Design: Case-control study. Setting: Research laboratory. Patients or Other Participants: Fourteen ankle coper participants (7M,7F; 20.2±1.9yrs; 168.7±9.5cm; 70.3±13.3kg), 9 participants with CAI (4M,5F; 20.7 ±2.2yrs; 170.5±9.9cm; 76.1±15.6kg), and 8 healthy control participants (8F; 20.6±1.1yrs; 162.9±4.1cm; 59.0± 6.8kg) volunteered. Interventions: Participants completed the FAAM and FAAM-sport, and performed the anterior reach of the SEBT (A-SEBT). Main Outcomes: Three trials of the A-SEBT (cm) were reported as a percentage of limb length (cm) of the participant (%MAXD). Scores on the FAAM and FAAM-Sport are represented as a percentage. Group means and standard deviations of the A-SEBT trials, FAAM, and FAAM-Sport were used for analysis. Separate one-way ANOVA's were used to compare the group means and standard deviations of the A-SEBT, FAAM, and FAAM-Sport. A Tukey's post-hoc test was applied in the event of statistical significance. Pearson product moment correlations were used to determine the relationship among dependent variables. Significance was set a priori at $P<.05$. Results: Significant group differences were observed for %MAXD ($F_{2,29}=11.03$, $P<0.01$), FAAM ($F_{2,29}=25.18$, $P<0.01$), and FAAM-sport ($F_{2,29}=24.62$, $P<0.01$) scores. For %MAXD, CAI patients (CAI=58.80%±6.05) performed worse than copers (67.79%±4.73, $P<0.001$) and controls (67.22%±2.47, $P=0.03$). For the FAAM, CAI scores (87.16%±5.61) were lower than copers (97.77%±2.39, $P<0.001$) and controls (98.66%±3.78, $P<0.001$). For the FAAM-Sport, CAI scores (74.63%±8.17) were lower than copers (93.08%±7.27, $P<0.001$) and controls (97.65%±6.62, $P<0.001$). %MAXD was significantly and moderately correlated with the FAAM ($r=0.50$, $P<0.01$) and FAAM-sport ($r=0.44$, $P<0.01$). Conclusion: Participants with CAI demonstrated decreased dynamic postural control on the A-SEBT and increased self-reported disability compared to copers and healthy controls. Furthermore, we observed a moderate correlation between self-reported disability measures and anterior reach of the SEBT, suggesting that participants with lower perceived ankle function may exhibit less dynamic postural control. Future research should identify the mechanism by which copers are able to retain these higher levels of function compared to patients with CAI.

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Correlation Between Plantar Cutaneous Sensation And Self-Reported Health In Individuals With Chronic Ankle Instability

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Context: Individuals with chronic ankle instability (CAI) have demonstrated decreased sensation on the plantar aspect of the foot compared to healthy individuals. It is unclear if this sensory deficit is related to decrements in self-reported measures of health or the injury characteristics often used to quantify the magnitude of CAI. Objective: To determine if plantar cutaneous sensation is correlated to self-reported measures of health or injury characteristics in individuals with CAI. Design: Correlational investigation. Setting: Laboratory. Participants or other Participants: Ten participants with CAI (2 male, 8 female, age=22.5±2.9years, height=171.6±10.1cm, weight= 71.4 ±13.2kg) were included. Inclusion criteria consisted of a history of one or more ankle sprains, two or more episodes of giving way in the previous three months, and answering "yes" to five or more questions on the Ankle Instability Instrument. Interventions: Participants reported to the laboratory for a single session. Sensation was assessed using Semmes-Weinstein Monofilaments (SWM) on three sites of the plantar surface (heel, base of the 5th metatarsal, head of the1st metatarsal). SWM were applied perpendicular to the skin for 1-2 seconds. Based on the participant's perceptual response, a heavier or lighter weight SWM was applied for the subsequent stimulus. An adapted staircase algorithm determined the lightest weight SWM which could be identified, representing the detection threshold. The detection threshold from all three sites was averaged for each participant and used for analysis. SWM are reported as an index value ranging from 1.65-6.65. Participants also completed self-reported measures of health including the Foot and Ankle Ability Measure-Sport (FAAM-Sport), Tampa Scale of Kinesiophobia-11 (TSK-11), and Disablement in the Physically Active Scale (DPA). The self-reported number of previous ankle sprains (PAS) and episodes of giving way (EGW) in the past three months were also recorded. Main Outcome Measures: Lower SWM detection thresholds represented greater sensitivity while higher FAAM-Sport, lower TSK-11, and lower DPA scores represented greater levels of self-reported health. Five separate Pearson Product Moment correlations (r) were performed and squared (r^2) to determine the relationship between plantar cutaneous sensation and measures of self-reported health, PAS, and EGW. Descriptive statistics were reported as mean±standard deviation. Alpha level was set a priori at $p<0.05$ for all analyses. Results: There was a significant correlation between SWM detection threshold (4.3±0.2) and PAS (5.9±4.1,$r=0.66$,$r^2=0.44$,$p=0.03$). There were no significant correlations between SWM detection threshold and the TSK-11 (18.8±4.9, $r=0.50$, $r^2=0.25$,$p=0.14$), the DPA (13.6±5.5, $r=0.34$,$r^2=0.12$,$p=0.33$), the FAAM-Sport (24.3±14.6, $r=-0.13$, $r^2= 0.02$, $p=0.72$), or EGW (8.1±8.1, $r=-0.35$, $r^2=0.12$,$p=0.32$). Conclusions: Individuals with CAI reporting a greater number of PAS exhibited higher SWM detection thresholds indicating decreased **sensitivity.** Although plantar sensation was not significantly correlated to measures of self-reported health, SWM detection threshold did explain 25% of the variance in TSK-11 scores. This suggests the relationship between plantar sensation and kinesiophobia warrants further investigation.

Relationship Between Functional Hop Tests And Patient-Orientated Outcomes After Anterior Cruciate Ligament Reconstruction

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Context: Individuals following an anterior cruciate ligament (ACL) reconstruction have a high risk of re-injury and problems with activities of daily living. Functional performance measures, such as the unilateral single-hop test, are frequently used in return-to-play decisions after ACL reconstructions. Minimal research has been done to evaluate if hop tests are related to an individual's pain and ability to perform normal activities of daily living. **Objective:** To evaluate if unilateral single-hop and triple-hop tests are associated with patient-oriented outcomes and if the hop tests can discriminate between injured and uninjured limbs. **Design:** Case Series **Setting:** Laboratory **Patients or Other Participants:** 52 participants (14 males, 38 females, age: 21±3, height: 170.9±7.0 cm, mass: 71.5±11.9 kg) with a history of at least one ACL reconstruction and currently without any physical activity restrictions in sports that involve cutting and landing volunteered to participate. **Interventions:** Participants completed a baseline demographic questionnaire and the International Knee Documentation Committee (IKDC 2000) questionnaire prior to testing. Participants performed two trials of the unilateral single-hop for distance followed by the unilateral triple-hop for distance on both injured and uninjured limbs. **Main Outcome Measures:** The IKDC is a valid patient-oriented outcomes questionnaire to evaluate

patients' pain, symptoms, and function of the knee post-surgically. The 2 trials from each jump were averaged together and normalized for body height. An asymmetry index was created for both hop tests (injured/uninjured). Pearson correlation coefficients were calculated to evaluate the relationship between hop test performance (single-hop, triple-hop, single-hop index, triple-hop index) and IKDC score. Paired t-tests evaluated the difference between injured and uninjured limb performance on the hop tests. **Results:** Neither hop test variable was significantly correlated with IKDC score (Mean±SD: 84.07± 10.85) (P>0.05). Both hop tests were able to detect differences between injured and uninjured limbs (Single-hop: Injured=0.88±0.15 % Body Height (BW), Uninjured =0.92 ±0.16%BH, P=0.004; Triple-hop: Injured =2.61±0.59%BH, Uninjured =2.74± 0.49%BH, P=0.02). **Conclusion:** Individuals after an ACL reconstruction continue to demonstrate deficits in functional hop performance after they have completed rehabilitation and are participating fully in physical activity. However, performance on functional hop tests does not appear to be an effective tool to measure current knee function and pain. Clinicians should evaluate both patient-oriented outcomes and functional performance.

There Is No Relationship Between Dynamic Balance And Knee Health Related Quality Of Life In ACL Reconstructed Patients

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Context: Knee health related quality of life (HRQOL) is an important indicator of recovery after severe knee injury such as rupture to the Anterior Cruciate Ligament (ACL). Clinical assessments of dynamic balance are often used during the rehabilitation process and to assist with return to sport decision making. However, the relationship between dynamic balance and knee HRQOL has not been examined. **Objective:** To determine if dynamic balance is related to knee HRQOL and if dynamic balance differs between reconstructed and healthy limbs. **Design:** Cross-sectional. **Setting:** Laboratory. **Patients or Other Participants:** Forty-nine patients with a history of unilateral ACL reconstruction volunteered to participate (14 males, 35 females, Height: 170.9±6.9cm, Mass: 75.2±23.8kg, Age: 20.7±2.9yrs, Average time from surgery=45 months). Patients were cleared to return to activity from their personal physician. **Interventions:** Dynamic balance was assessed via the star excursion balance test in three directions: anterior (ANT), posteromedial (PM), and posterolateral (PL). All individuals completed 4 practice and 3 recorded trials on the healthy and reconstructed limbs. Subjects were instructed to reach as far as possible whilst keeping their hands on their hips. Patients also completed a knee HRQOL questionnaire (IKDC 2000 Subjective Form). **Main Outcome Measures:** Reach distances were measured in centimeters (cm) and normalized to leg length (%) in each direction. A composite score (CS) for each limb was also calculated by adding reach distances in each direction and dividing by three times the limb length. Relationships were examined by calculating pearson correlation coefficients between IKDC scores and SEBT composite scores and individual reach measurements. Paired t-tests were used to examine reach distances between healthy and reconstructed limbs (P<.05). **Results:** No significant relationships were observed between IKDC score and reach distances in the reconstructed limb (ANT: 81.8±20.4%, r = -0.18, P=0.21; PM: 89.5±14.3%, r = -0.07, P=0.61; PL: 86.4±17.3%, r = -0.03, P=0.83; CS: 85.9±15.6%, r = -0.11, P=0.44). However, the reconstructed limb did have deficits in reach distance in the ANT direction (Injured: 80.7±20.6%, Uninjured: 82.4±20.9%, t = -2.5, P=0.02). All other findings were not significant (P>0.05). **Conclusions:** Deficits in dynamic balance exist after ACL reconstruction. However, there is no relationship between dynamic balance and knee HRQOL in individuals with ACL reconstruction. Clinical assessments of dynamic balance may still hold promise for assisting with return to sport but may not be a good indicator of knee HRQOL. Additional research is needed to develop these relationships. Studies should examine these variables in reconstructed individuals at similar time frames following surgery and after their return to activity. Supported by the UW Sports Medicine Foundation.

Comparison Of IKDC And SANE Outcome Measures And Establishing MCID Following Knee Injury In Active Females

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Context: Knee injury among young active females remains a pressing public health issue. Clinicians are being called upon to pay greater attention to patient-oriented outcomes to better evaluate the impact of these knee injuries. Little agreement exists on which outcome measures are best and clinicians cite several barriers to their clinical use. Single Assessment Numerical Evaluation (SANE) may provide meaningful outcome information while lessening the time burden associated with other patientoriented knee measures. Objective: The purposes of this study were to determine the correlation between a SANE assessment and the 2000 International Knee Documentation Committee (IKDC) questionnaire and to determine the minimal clinically important difference (MCID) for the SANE score in a population of active young females following knee injury from pre-injury through one year follow-up. Design: Observational prospective cohort. Setting: Data were collected at a sports medicine clinic and university health service. Participants: A convenience sample of 263 high school and college females (age = 17.8 ±1.6 years) who were diagnosed by a physician with a knee injury that was a result of participation in sport or regular fitness activities. Interventions: Knee function was assessed using IKDC and SANE at pre-injury, by recall, at diagnosis, 3, 6, and 12 months post-injury. Main Outcome Measures: Pearson's correlation coefficients (95%CI) were calculated to assess relationship and strength of association. Comparison of mean responses ($p < 0.05$) in SANE and IKDC was assessed by repeated measures ANOVA (RM-ANOVA). MCID was calculated for SANE using known IKDC MCID values as an anchor. Logistic regression models using improved status as the dependent variable and change from baseline of SANE as the independent variable were developed. MCID for SANE at each time point was the value that maximized the sensitivity and specificity of the receiver operating characteristic (ROC) curve from the logistic model. Results: Moderate to strong correlations were seen between SANE and IKDC (0.65-0.83). SANE, on average, was 2.7 (95% CI: 1.5, 3.9; p-value < 0.001) units greater than IKDC over all time points. At baseline (p=0.005), 3 months (p=0.010), and 12 months (p=0.031) SANE was statistically significantly higher than IKDC. The MCID for SANE at 6 months was calculated to be 7 (sn 89.7%, spc 67.9%). The MCID for SANE at 12 months was calculated to be 19 (sn 87.4%, spc 72.5). Conclusions: SANE and IKDC scores were strongly correlated across all time points from pre-injury to 12 month follow-up. The ability to calculate the MCID gives added meaning to the SANE score and allows for greater clinical application for a range of knee injuries. Providing clinicians with patient-oriented outcome measures that can be obtained with little clinician and patient burden may allow for greater acceptance and use of outcome measures in clinical settings.

Morel-Lavallee Lesion In A Male High School Soccer Player

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Background: A male, 18 year old, high school soccer player presented with edema over the VMO and joint stiffness of the right knee. Additional symptoms included a description of feeling a 'weight' on the knee with a burning sensation when in contact with fabric. The patient reported a mechanism of the right knee sliding with anterior medial contact on the ground, causing a sheering force between the dermal layers and underlying structures. The patient reported a feeling that the patella was stationary in contact with the ground while the medial tibiofemoral joint continued. Two initial evaluations at the time of the MOI, by different physicians found a structurally sound knee examination and no reason to cease activity. The patient continued to play for the 4-month period before seeing the current primary physician. Upon evaluation, the physician again found a structurally sound knee with minimal tenderness over the quadriceps tendon and pes anserine burse with edema over the VMO area. **Differential Diagnosis:** Differential diagnoses were a ruptured bursa with nerve damage, bone contusion, quadriceps tendonitis, and pes anserine bursitis. **Treatment:** X-rays were negative and the patient was treated with an injection into the pes anserine bursa of lidocaine and dexamethason. Follow up care instructions included the use of GameReady, Voltaren creame, a DonJoy reaction knee brace and physical therapy. During the first physical therapy session, the edema significantly increased. Drainage of 30 cc of serous fluid were aspirated from the VMO area and sclerosing agents were injected, followed again by the use of a GameReady. An increase in the effusion presented six days later. Blood-tinged joint fluid was removed and an MRI was ordered.The MRI revealed subtle marrow edema at the medial femoral condyle with no joint effusion. A large fluid collection, termed a Morel-Lavellee lesion (MLL), in the anteromedial soft tissues peripheral to the medial retinaculum measuring 10 cm in length in a crescent configuration was found. Surgery was performed within the following month. A fibrous membrane measuring 15 cm proximal/distal, 8 cm medial/lateral was removed, the area was irrigated with bacitracin-impregnated saline, a Wound VAC on continuous suction and knee immobilizer were put in place. Six days later an irrigation and debridement with the delayed primary closure and removal of the Wound VAC took place. The patient was given a Kneehab XP and remained in the knee immobilizer for another four weeks. The patient continues with rehabilitation and treatment maintenance. Reappearance of symptoms have been controlled within the past month and progression to return to play has begun. **Uniqueness:** MLL, is simply defined as a closed degloving injury caused by a shearing force to the skin. Pseudocysts form at the site, causing reoccurring fluid accumulation consisting of blood, lymph, and necrotic fat. It commonly occurs in the greater trochanter, lower back and gluteal regions due to their greater propensity to shearing forces. It is very rare for a MLL to occur in the knee/quadriceps region. Due to the separation of the dermal layers and subcutaneous tissue from the underlying fascia, proper healing and preventing reoccurrence is difficult. **Conclusions:** A MLL of the knee is a rare injury. Due to the infrequency, recognition is challenging for all health care providers. Size and location help differ MLL from a bursa injury. As an athletic trainer, witnessing the shearing mechanism of injury and, recognizing the primary symptom of recurrent edema associated with a MLL may prevent a patient from progressing to surgery. Gradual progression in exercises and return to play are needed to prevent the reoccurrence of fluid accumulation during conservative treatment as well as after surgical removal.

A Case Of Benign Paroxysmal Positional Vertigo In A High School Football Athlete

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Background: An 18 year old male high school football center experienced benign paroxysmal positional vertigo (BPPV) during summer football camp and through the high school football season. The first episode occurred during football camp in the summer. The patient was originally seen by his family physician who diagnosed him with BPPV. Care was transferred to the athletic trainer working with his high school football team. Symptoms included severe nystagmus, nausea, migraines and dizziness. Patient had a positive Dix-Hallpike maneuver test. Dix-Hallpike maneuver test involves moving the patient from an upright position to a supine position with the head at 45 degrees rotation in cervical extension. Torsional upbeating nystagmus indicates a positive test. **Differential Diagnosis:** Concussion, tinnitus, central nervous system disease, vestibular neuritis, motion sickness, vestibular migraines, or méniére's disease No diagnostic imaging was performed. **Treatment:** BPPV was diagnosed based on the patient's symptoms and positive Dix-Hallpike maneuver test. Treatments included the Epley maneuver and Semont maneuver. The maneuvers were performed on the sidelines, the athletic training room or in a doctor's office. Both treatments involved displacing the patients head in order to dislodge the otholiths (calcium crystals lodged in the semicircular canals) to allow the endolymph (fluid of the inner ear) movement in order to establish the equilibrium of the athlete. The Epley maneuver was performed by turning the head of the patient to the affected side and placing the neck in as much cervical extension as possible. The athletic trainer waited for the nystagmus to stop then rotate the head to the opposite side, waiting for nystagmus to subside and then rotate the athlete to their side. After two minutes, the patient sat up in normal position. The Semont maneuver was executed if the episode continued. The Semont maneuver was performed by turning the patient to the unaffected side and putting the patient in a prone position until the nystagmus subsides. When the nystagmus subsided the patient was then forcefully thrown to the opposite end of the table to a supine position. This process was repeated twice and the patient was then returned to a sitting position. If neither of these treatments worked, the patient was not allowed to compete until symptoms subsided. Many times the Epley maneuver resolved the symptoms. However, occasionally both treatments were used and unsuccessful. Signs and symptoms subsided one week after football concluded. He is currently participating in football at the collegiate level with no recurrence of symptoms. **Uniqueness:** In about 50-70% of BPPV no specific cause is found. The incidence's of BPPV occurring in males and in a population under 55 is rare. Mean age of patients suffering from BPPV has been reported as 51-57.2 years. This patient had no true onset or triggers for his episodes. The onset of symptoms occurred on the bus, after a hit to the helmet, or upon standing. There were days that he did not have any symptoms and days when he couldn't function because the symptoms were severe. **Conclusions:** A high school player experienced vertigo and was able to continue playing football. The Epley and Semont maneuvers were performed to treat the patient. Vertigo is believed to be an older adult illness leading to the lack of knowledge in the athletic population. Several factors can be overlooked with an injury like this because of its uniqueness and lack of awareness in our field. Even though the injury is not life threatening, it is a serious condition of the inner ear and immediate treatment is crucial to prevent the condition from getting worse.

Kienböck's Disease In A Collegiate Softball Player: A Case Report

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Background: A 20 year-old collegiate softball pitcher presented with diffuse, intermittent pain in her non-dominant wrist during pre-season, which she explained had occurred for one year at the collegiate level and four years prior. Pain varied with a systematic progression noted during pre-season training. The athlete noted pain on physical examination with active wrist extension and flexion and localized tenderness to palpation over the dorsal and volar radiocarpal joint. Symptoms appeared to be idiopathic, as the athlete denied history of trauma or known mechanism of injury. The athlete had a history of type I diabetes. **Differential Diagnosis:** Extensor tenosynovitis, scapholunate instability, lunotriquetral instability, triangular fibrocartilage complex tear, scaphoid fracture, Kienböck's disease, ganglion cyst, pisiform pathology, avascular necrosis of the capitate, and posterior interosseous nerve compression syndrome were considered. **Treatment:** The athlete's pain responded positively to a conservative regimen of bracing and strengthening for one year and was able to maintain full sport participation. Pain increased during the following fall off-season training, and she was subsequently referred to an orthopedic hand specialist. Plain film radiographs and MRI revealed avascular necrosis of the lunate (Stage II Kienböck's disease). Repeat radiographs following 6 weeks of conservative management (immobilization) revealed no change in bone healing, and pain persisted; therefore, a radial osteotomy to reduce pressure on the lunate was performed. Surgery was postponed for 6 months due to the athlete's inability to control her blood glucose levels. Upon clearance from her treating endocrinologist, pre-surgery radiographs demonstrated Stage III progression with beginning stages of lunate collapse. At this time, a 2 mm radial shortening osteotomy was performed, 7 months after the initial orthopedic examination. The athlete was immobilized immediately following surgery for 6 weeks and underwent a subsequent 6-week bout of physical therapy to restore range of motion at the wrist. She is currently 6 months post surgery, and pain free with full active range of motion, but has been advised to cease competitive softball due to the progressive degeneration of the disease. **Uniqueness:** Kienböck's disease is most commonly found in male patients ages 20-40 years, with males twice as likely to develop the disease. The etiology is unknown, but is often associated with repetitive microtrauma and commonly found in manual workers. Kienböck's disease has been reported infrequently in the adolescent athletic population, but has been seen in those with prior trauma or repetitive stress, such as weight bearing in gymnastics. This case involves an athlete's non-dominant wrist, with no history of trauma, but moderate repetitive stresses from utilizing the ipsilateral hand to catch in softball. Additionally, the athlete had advanced stages of the disease, but did not demonstrate the normal progression of loss of flexion and extension, nor steadily increasing pain, which made this case particularly difficult to detect promptly. Prognosis is likely time dependent, and the delay of surgical intervention due to poor management of her type I diabetes may have contributed to the allowed progression of the disease. **Conclusions:** Younger patients with Kienböck's disease yield positive outcomes from surgical intervention if detected early. As the disease progresses, individuals are more susceptible to irreversible arthritic damage, which may yield long-term disability. Early detection and referral is essential in reducing the sequelae of injury associated with Kienböck's disease, and its presence should be considered in the differential diagnosis of individuals presenting with increasing chronic wrist pain.

Paget-Schrotter Syndrome In A Collegiate Volleyball Player: A Case Study

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Background: A 20-year-old Division I male volleyball player presented with a swollen, discolored right arm that was cold to touch before a fall pre-season training session. He had no previous upper extremity injuries, and there were no family history of vascular disease. The athletic trainer performed shoulder and upper extremity evaluations and no structural damage was noted. He then proceeded with clinical tests to determine thoracic outlet syndrome (TOS) which were positive. Differential Diagnosis: Neurologic thoracic outlet syndrome (nTOS); venous thoracic outlet syndrome (vTOS) otherwise known as Paget-Schrotte Syndrome (PSS); arterial thoracic outlet syndrome (aTOS); deep vein thrombosis (DVT); brachial plexus injury, thoracic discogenic pain dyndrome, cervical discogenic pain syndrome. Treatment: Athlete was referred to the team physician, who ordered diagnostic images to confirm TOS. Initial ultrasound (12/7/11) was inconclusive for TOS. Follow-up MRI (12/13/11) and MRA (12/14/11) was performed of the right shoulder, which showed DVT in the right subclavian vein. The day after the test, a thrombolysis was performed (12/15/11). Athlete was given clearance to return to activity when spring season practice started, which was two weeks post procedure. After one week of practice, symptoms started to return in the athlete's right arm accompanied with pain (1/5/12). This time, athlete was referred to a vascular surgeon, who ordered another MRA (1/13/12) and a CT scan (2/27/12) of the right shoulder and the chest. The athletic trainers worked with the athlete in effort to relieve the external pressure caused by the tight musculature surrounding the vein. Myofascial release, massage, stretching, and postural rehabilitation to correct the rounded shoulder were performed. When symptoms did not improve, athlete was seen by another vascular surgeon who recommended surgical intervention. (4/18/12). During surgery (5/3/12), it was noted that subclavius and middle scalene was hypertrophied two-times the normal size, and the anterior scalene muscle was three-times the normal size. Therefore, subtotal resection of subclavius, anterior, and middle scalene muscles were performed, along with resection of the first rib on the athlete's right side through the axilla. Two weeks post-surgery, athlete was given clearance to begin rehabilitation without restrictions. A venogram procedure was performed two weeks post-surgery (5/23/12) and findings showed normal blood flow restoration. The athlete was given clearance to begin volleyball activity once strength and range of motion was bilaterally equal (6/6/12). Today, athlete is fully recovered and participating in NCAA Division I men's volleyball team. Uniqueness: Approximately 95% of the cases of TOS are called the neurologic type, in which the brachial plexus are compressed by surrounding tissues. The PSS is a venous type TOS, in which the vein is obstructed causing spontaneous axillosubclavian vein thrombosis. It accounts for approximately 3-4% of TOS. The etiology is similar, in which both cases are seen in patients who participate in excessive upper extremity activities with prolonged hyperabduction and external rotation of the shoulder. However, in PSS patients, the strain causes microtraumatization of the venous intima that result in local coagulation and formation of venous thrombosis. It is not know why certain individuals develop one form of TOS over another. Conclusions: Although rare, PSS should be considered in the differential diagnosis for upper extremity conditions. Early correct diagnosis and prompt care is crucial to the speedy recovery of the patient. Although rare, incidence of pulmonary embolism associated with PSS has been reported in as high as 30% of the cases. Athletic trainers should familiarize themselves with the different TOS conditions, as well as treatment options for each of the three conditions. For PSS, thrombolysis followed by 1st rib resection seems to be the standard of care for PSS and acute subclavian vein thrombosis.

Klippel-Feil Deformity In A High School Football Player

Iannetta T, Smith J: Cleveland Clinic, Cleveland, OH

Background: This is a 16 year-old defensive back playing football who presented to the athletic training room the morning following the previous night's football game. His chief complaint was bilateral neck and trapezius pain with left being greater than right. He admitted that he may have sustained a "stinger" in the game while making a tackle which he did not report to the medical staff. Physical exam by the ATC demonstrated full cervical and shoulder active range of motion with no radicular symptoms bilaterally. Negative Spurlings and brachial plexus test. Cervical and shoulder strength 5/5. Treatment consisted of rest, ice, gentle range of motion and flexibility exercises. The athlete completed the remainder of the season with no reported reoccurrence. Upon completion of the football season, he returned to the athletic training room complaining of pain at the base of his neck and a headache after performing a military press and bench press during a weight training class. He denied any radiating pain at this time. The athlete was referred for further evaluation and diagnostic testing. **Differential Diagnosis:** Cervical sprain, cervical strain, brachial plexus lesion, cervical facet syndrome, herniated cervical disc, concussion, exertional headache, Klippel-Feil deformity. **Treatment:** Physician workup for concussion-like symptoms was negative. Evaluation showed mild suboccipital tenderness, no midline cervical tenderness, and full cervical range of motion with pain upon flexion, left lateral side bend and rotation. Upper extremity strength was 5/5 and symmetric. Reflexes were symmetric at biceps, triceps and brachioradialis. No sensory loss in the upper extremities. Negative Spurlings maneuver. X-rays were ordered and showed rudimentary C6-C7 disc space with fusion of C6-C7, unfused C7 spinous process, pseudosubluxation at C3-C4, C4-C5, C5-C6. A MRI was also ordered and results were fusion of the C6-C7 vertebral bodies with a rudimentary intervening vertebral disc. The right lamina of C7 is deficient. Partial fusion of the left C6-C7 lamina and spinous process. The canal and neural foramina are widely patent from C1-2 to C7-T1. The final working diagnosis is that of Klippel-Feil deformity. Recommendation to the athlete and his parents was to discontinue football due to his congenital fusion. This would put him at a greater risk for a cervical spinal cord injury. The athlete was then referred to a spine specialist who had the same recommendations after examining and reviewing the athlete's x-rays and MRI. **Uniqueness:** Brachial plexus injuries and cervical sprains and strains are not uncommon in the sport of football. This athlete had a single reported incident of a possible brachial plexus injury which resolved quickly. However, other symptoms were reported after starting weight training which necessitated further evaluation. Although, these symptoms could have been something as common as cervical strain or exertional headache other abnormalities needed to be ruled out. Klippel-Feil deformity is usually associated with other disorders such as defects in other organs including the inner ear, spinal cord, heart and genitourinary tract. This athlete did not present with any of these defects. **Conclusion:** This athlete was unable to continue collision sports such as football due to the risk of a cervical spinal cord injury. However, through rehabilitation to maintain his range of motion, flexibility and strength, he was allowed to play baseball. He had a very successful season without any further exacerbation of his condition.

Free Communications, Oral Presentations: Prehospital Care of the Injured Athlete

Tuesday, June 25, 2013, 11:00AM-11:45AM; Palm D; Moderator: Julianne Schmidt, MA, ATC

Facemask Removal Of Commonly Worn Lacrosse Helmets

Ryan C, Paden A, Tierney RT, Bright N, Higgins M: Temple University, Philadelphia, PA, and Towson University, Towson, MD

Context: In the event of a head or neck injury in equipment-laden sports, it has been recommended to remove the facemask rather than the entire helmet for access to the airway. Research surrounding facemask removal, however, has focused primarily on football helmets, which are structurally different than lacrosse helmets. To date, there has been limited published research regarding men's lacrosse helmet facemask removal. **Objective:** To determine the effect of lacrosse helmet type on facemask removal time and rate of perceived exertion (RPE). **Design:** A single factor repeated measure design. **Setting:** Controlled laboratory setting. **Participants:** Eight certified athletic trainers (male = 4, female = 4; age = 24.13 ± 2.17 yr, experience = 1.75 ± .71 yr). No exclusionary criteria existed. **Interventions:** Each subject participated in a familiarization session and testing session for each helmet. The familiarization session consisted of watching a video demonstrating the removal technique followed by two successful facemask removals for each helmet. Within a week, each subject returned for a testing session in which they participated in a timed facemask removal and reported the RPE afterwards. All facemasks were required to be removed within a four-minute time limit to be considered successful. The independent variable was helmet type (Warrior Venom (WV), Cascade CPX-R (CC), Cascade Pro7 (CP), and Riddell Revolution (RR)). **Main Outcome Measures:** The dependent variables were facemask removal time (seconds) and RPE (Borg Scale 0-10). Two one-way (1x4) repeated measures analyses of variance (ANOVA) and paired samples t-tests were used to analyze significant differences ($p < .05$) in removal time and RPE between helmet types. **Results:** The ANOVAs revealed statistically significant differences for removal time, $F(3,21) = 43.22$, $p < .001$, and RPE, $F(3,21) = 6.96$, $p = .002$. The CP (63.3 sec) facemask took 61%, 93%, and 108% longer to remove than the WV (39.3 sec; $p = .001$), CC (32.7 sec; $p = .001$), and RR (30.5 sec; $p = .001$), respectively. The WV facemask took 29% longer to remove compared with the RR ($p = .002$). The participants found the CP (3.4) to be 59%, 100%, and 199% more difficult than the WV (2.1; $p = .049$), RR (1.7; $p = .022$), and CC (1.1; $p = .005$), respectively. There were no other statistically significant differences identified. **Conclusion:** The CP facemask was the most time consuming and difficult to remove likely due to having five removal sites versus three removal sites on the remaining three helmets. All of the facemasks, however, were successfully removed well within the four-minute time limit for removal. These data suggest that lacrosse facemask removal for these helmets is a viable option for lacrosse athlete airway access.

The Effects Of Equipment Design On Cervical Spine Motion, Removal Time, And Difficulty During Football Shoulder Pad Removal

Bric JD, Swartz EE, Al-Darraji SJ, Decoster LC, Mihalik JP: University of New Hampshire, Durham, NH; New Hampshire Musculoskeletal Institute, Manchester, NH; University of North Carolina, Chapel Hill, NC

Context: Football equipment designs continue to evolve, providing better protection for athletes participating in collision sports, including American football. Recent shoulder pad equipment designs depart considerably from the traditional equipment many football athletic trainers (ATs) are familiar with. These evolutions may affect cervical spine injury management, when ATs are required to intervene quickly and safely to provide resuscitation and advanced cardiovascular care. **Objective**: To compare the amount of head movement, time to task completion, and perceived difficulty during removal of traditional and quick-release shoulder pads. **Design**: Quasi-experimental. **Setting**: Research laboratory. **Patients or Other Participants**: Forty ATs free of physical pathology preventing them from completing the required tasks were recruited (males=21; females =19; age=33.7±11.2 yrs; mass= 80.7±17.1 kg; height= 173.1±9.2 cm; AT experience =10.6±10.4 yrs). **Interventions**: The independent variable was shoulder pad design (Traditional or Riddell RipKord™). After familiarization, participants working in pairs conducted 8 successful trials in random order whereby they removed traditional (using the flat torso technique) or RipKord™ shoulder pads from a live model (4 trials of each). An eight-camera three-dimensional motion

system and two three-point segment marker sets (head and torso) were used to capture head motion. Total time was recorded with a digital stopwatch. The difficulty for the task by the participant was recorded after each trial using a modified Borg CR-10 scale. **Main Outcome Measures**: Dependent variables included head excursion in degrees (computed by subtracting minimum position from maximum position) in each of the three planes (sagittal, frontal, transverse) during shoulder pad removal, time to task completion, and difficulty rating. Trials for each team were ensemble averaged. Paired-samples *t*-tests were employed to evaluate differences between the two levels of our independent variable for each dependent variable. **Results**: Athletic trainers required significantly less time to remove the RipKord™ shoulder pads (21.96 ± 3.08 s) than traditional shoulder pads (29.22 ± 4.45 s) in our study (t_{19} = 9.80; P<0.001). There were no significant differences in sagittal (t_{19} = 1.63; P=0.119), frontal (t_{19} = 0.80; P=0.435), or transverse (t_{19} = 1.10; P=0.285) cervical spine motion resulting from shoulder pad removal between the two designs. There were no differences in difficulty reported by the ATs in removing the two shoulder pad designs (t_{19} = -0.80; P=0.435). **Conclusions**: Our data suggest that the new RipKord™ design allows ATs to remove shoulder pads more quickly, without compromising cervical spine motion or introducing additional difficulty to the task. These results can only be generalized to the flat torso technique of shoulder pad removal at this time. Future research should examine the efficacy of such shoulder pad designs in allowing for effective access to the chest as would be needed in cardiovascular emergencies. Incorporating these equipment advances to other sports should be considered. *This study was funded by the Eastern Athletic Trainers' Association.*

Athletic Training Services Associated With Emergency Preparedness & Planning In SC High School Athletics

Wham GS, Saunders RP, Mensch JW: University of South Carolina, Columbia, SC, and Lexington School District 1, Lexington, SC

Context: Recent research suggests South Carolina(SC) schools with AT services provide higher levels of medical care; however, no research has examined the relationship between AT services and components of emergency planning/preparedness. **Objective:** To examine the relationship between existence of AT services in a school and compliance with recommendations for emergency planning/preparedness identified in the Appropriate Medical Care for Secondary School-aged Athlete (AMCSSAA) Consensus Statement/ Monograph. **Design:** Cross-sectional study. **Setting:** Mailed/emailed survey. **Participants:** 63% **(**166/263) of SC high schools. **Intervention(s):** SC high schools were surveyed regarding existence of AT services(independent variable) and existence of components of appropriate medical care related to emergency planning/preparedness. After pilot-testing, data were collected via a systematic, modified-Dillman approach. Test-retest reliability was strong (r=.89). **Main Outcome Measure(s)**: AMCSSAA Monograph recommendations related to components of emergency planning/ preparedness were identified, summarized, re-phrased as policies or practices, and included as survey items. Items were scored 3, 2, 1, or 0 on a 4-point scale. Higher scores indicated more favorable provision of medical care. Each component served as a dependent variable: Existence of Emergency Action Plan(EEAP), EAP Reviewed Annually(EAPRA), EAP Reviewed Post-emergency(EAPRP), EAP Posted in Facilities(EAPPF), Coaches CPR/AED certified(CCAC), Coaches First-aid certified(CFAC), Vacuum Splints Available(VSA), Spine Board Available(SBA), Cervical Collar Available(CCA), Facemask Removal Device Available(FRDA), AED Available(AEDA), CPR Mask Available(CPRMA), Shoulder Sling Available(SSA), Crutches Available (CA), Blood Pressure Cuff/ Stethoscope Available(BPSA), Latex/ nitrile Gloves Available(LNGA), Ice Bags Available(IBA), and First-aid Kit Available(FAKA). SPSS was used to calculate descriptive statistics and multiple comparison tests. **Results:** Significant differences existed between schools with AT services and those without AT services for the following components of emergency planning/preparedness: *EEAP* [AT 2.48(.78) and no AT 2.11(1.02),F=5.5, p<.02], *EAPRA* [AT 1.88(1.06) and no AT 1.46(1.09),F=4.27,p<.04], *EAPRP* [AT 1.85(1.03) and no AT 1.33 (1.08),F=7.32,p<.01], *VSA* [AT 2.13(1.05) and no AT .86(1.05), F=41.71,p<.0001], *SBA* [AT 1.65(1.23) and No AT .70(.93), F=18.98,p<.001], *CCA* [AT 1.77(1.20) and No AT 1.04(.17), F= 12.46,P<.001], *FRDA* [AT 2.51(.91) and No AT 1.75(1.25),F=16.83, P<.001], *CPRMA* [AT 2.54(.82) and No AT 1.41(1.17),F=44.46,P<.001], *SSA* [AT 2.54(.82) and No AT .80(.98),F=25.57,P<.001], *CA* [AT 2.59(.74) and No AT 1.54(1.23), F=41.39,P<.001], *BPCSA* [AT 2.36(1.01) and No AT 1.18(1.24), F=35.41,P<.001], *LNGA* [AT 2.88(.37) and No AT 2.42(1.01), F= 17.91,P<.001]. No significant differences were identified between schools with AT services and schools without AT services for: *CCAC*, *CFAC*, *EAPPF*, *AEDA*, *IIBA*, and *FAKA*. **Conclusions:** In SC high schools, schools without AT services were found to lack many components required to provide appropriate medical care related to emergency planning/preparedness. These results provide guidance for decision-makers (school administrators and

legislators) and those who influence decision-makers (parents and athletes) in improving medical care provided for interscholastic athletes.

Spine Evidence-Based Forum

Tuesday, June 25, 2013, 12:00PM-1:00PM, Palm D; Moderator:

Retrospective Clinical Case Series Of Sudden Death During Physical Activity In The Collegiate Setting: July 2011 – June 2012

Adams WM, Pryor RR, Pagnotta KD, Vandermark LW, Stearns RL, Casa DJ: Korey Stringer Institute; University of Connecticut, Storrs, CT

Background: We sought to investigate all cases of sudden death during National Collegiate Athletic Association (NCAA) sanctioned sporting events from July 1, 2011-June 30, 2012. An online LexisNexis and subsequent media search resulted in four student athletes, all of whom were male (2 basketball players, 1 football player, and 1 baseball player; Mean±SD: age=20±1y, height= 187±7cm, weight=97±15kg), who died while participating in their respective sport. A 22-year-old Caucasian Division III football player (athlete A) collapsed during an August football practice while being escorted off the field by the athletic training staff. He was complaining of a headache from a helmet-to-helmet collision. A 21-year-old Division II African American basketball player (athlete B) collapsed during an early September men's basketball conditioning session and later died at the hospital. A 19-year-old Division III African American basketball player (athlete C) collapsed during preseason basketball practice that took place at the end of September. The fourth student athlete was a Division I Caucasian baseball player (athlete D) who collapsed during an offseason conditioning session in late October, 2011 with seasonably warm temperatures (high of 64°F) that day. **Treatment:** Athlete A was being evaluated by one of the school's staff athletic trainers and upon collapse was rushed to the hospital where he underwent emergency surgery to relieve swelling in his brain. Coaches performed cardiopulmonary resuscitation (CPR) on athlete B before he was rushed to the hospital. Athlete C collapsed after complaining of vision problems and cramps. He was rushed to the hospital with an extremely elevated body temperature. After athlete D collapsed, he was taken to a local hospital where his core body temperature was initially recorded as 105.9°F and peaked at 107.9°F. He was treated for exertional heat stroke once he arrived at the hospital and later treated for multi-organ failure. Throughout treatment, he had to be resuscitated five times and surgeons had to remove his right lung. **Results:** Athlete A died due to complications from a traumatic brain injury. The cause of death for athlete B remains unknown but is speculated to be the result of cardiac arrest. Lab results were positive for the chemical JWH-018 in athlete C, which is used to make synthetic marijuana. He died four days after being admitted to the hospital. Official cause of death is listed as drug toxicity due to the presence of the synthetic chemical but it is speculated that the athlete either died of exertional sickling or exertional heat stroke. Three days after being admitted to the hospital and treated for exertional heat stroke and the resulting multi-organ failure, athlete D died due to resulting complications. The official cause of death is inconclusive but is speculated to be from exertional heat stroke. **Uniqueness:** Of the four-presented cases, three of the deaths occurred during conditioning sessions prior to the start of their NCAA sport season. None of the deaths occurred during game participation. Similar to previous research, the majority (or all) deaths were males, conversely, the deaths were evenly distributed between Caucasian and African American athletes. **Conclusions:** The four cases of death in the NCAA level from July 1, 2011-June 30, 2012 occurred during the fall of 2011. Three of the four deaths occurred during offseason or preseason conditioning sessions where medical staff was not present (an athletic trainer was only present at the football practice of athlete A with no medical coverage during the conditioning sessions of athletes B, C, and D). The health and safety of collegiate athletes during offseason conditioning sessions should be further investigated.

Sudden Collapse Of A Middle School Baseball Player

Williams SJ, Kamp A: University of Kentucky Orthopaedic Surgery and Sports Medicine and University of Kentucky Department of Cardiology, Lexington, KY

Background: A 14 year old middle school baseball player with no contributory medical history suddenly collapsed following 30 minutes of drills at high school baseball conditioning. He fell face first to the ground and did not move. The athletic trainer was called. When she arrived, the athlete had agonal breathing. Carotid pulses were checked and the athletic trainer began cardiopulmonary resuscitation (CPR). The coaches activated the emergency action plan, calling 911 and getting the automated external defibrillator (AED). The athletic trainer administered CPR and used the AED during the 6 minutes before paramedics arrived. The defibrillation detected a rhythm of ventricular tachycardia. It is believed that the patient did regain a pulse. EMS arrived shortly thereafter and the patient was again in ventricular tachycardia and received two more defibrillations. CPR administered by the Lewis device was continued in progress to the emergency department where the patient had a pulse intact. **Differential Diagnosis:** Hypertrophic cardiomyopathy (HCM), myocarditis, catechol-aminergic polymorphic ventricular tachycardia (CPVT), drug or supplement use, sudden cardiac arrest with indeterminate cause. **Treatment:** Once at the emergency department, the athlete continued to be in sinus tachycardia with a good carotid pulse. EKG performed showed evidence of nonspecific ST and T wave changes. His drug test was negative. He was admitted to Pediatric Cardiology in the Pediatric Intensive Care Unit. Subsequent head CT was unremarkable and echocardiogram showed no HCM but a decreased filling of the left ventricle. The athlete was taken off intubation and awoke the next day. His repeat EKG was normal sinus rhythm and no delta wave. On the third day, the athlete experienced some delirium and was combative. He was unable to have a cardiac MRI performed due to his mental status. Daily EKGs were continued with no abnormalities. Electroencephalography (EEG) was performed and found to be normal. The athlete was then transferred to the Progressive Care Unit (PCU). After the cardiac MRI was performed, the results were within normal limits. It was then recommended to have an epinephrine push to elicit CPVT. Cardiac catheterization was performed and coronary artery origins and courses were normal. Endomyocardial biopsy results were normal and adenosine administration demonstrated no evidence of Wolff-Parkinson-White syndrome. Following exhaustive testing that was inconclusive, an implantable cardioverter-defibrillator (ICD) was placed to detect any future cardiac arrhythmia and to correct the arrhythmia with a shock. The athlete was discharged from the hospital 12 days after collapse. **Uniqueness:** The athlete had no personal or familial medical history to predispose him to a cardiac event. Allowing patients with ICDs to participate in sports has long been contra-indicated. Recent research is showing that athletes with ICDs have no more risks during sports than patients who do not participate in moderate activities. **Conclusions:** A 14 year old athlete's sudden collapse during a low intensity workout is uncommon. Athletic trainers should understand how to first deal with a sudden cardiac arrest, and also understand the benefits and risks associated with having an athlete who participates in competitive sports with an ICD. Currently this athlete has decided to discontinue playing baseball and has begun to play golf. He is also involved in the ROTC program at his high school. Genetic testing was completed and detected a mutated abnormality in a gene with no known correlation. It is unclear if a diagnosis will ever be determined.

Sudden Myocardial Infarction In A 19-year-old Division I Football Lineman With No Prior Indicators

Ward BL, Hanley M, Lopez R: East Carolina University, Greenville, NC, and University of South Florida, Tampa, FL

Background: In this case, a 19-year-old African American male football player (6'7", 326.8 lbs.) with no significant previous medical history reported having chest pain associated with nausea, diaphoresis, shortness of breath, and a severe cough after a winter evening workout. The initial evaluation consisted of a standing/resting pulse, heart rate, and temperature. The immediate diagnosis was that the pain experienced was likely attributed to extreme physical exertion further aggravated by a previous upper respiratory infection. The athlete denied any family history of cardiac conditions. The athletic trainer instructed the athlete to go to his dorm room to rest, and to call him immediately should his symptoms persist, or if he experienced any pain and/or numbness in his upper extremities. The athlete's pain fluctuated for about four hours, after which he started having numbness in his extremities and back pain. The athlete subsequently drove himself to student health services, where he was met by the athletic trainer and driven to the hospital. **Differential Diagnosis:** Viral illness, exertional sickling, hyperlipidemia, muscle strain, myocardial infarction, systemic disease. **Treatment:** Upon arriving at the emergency room, the athlete received nitroglycerin sublingually, which relieved his pain completely. Testing revealed the athlete had abnormally high cardiac enzymes, troponin's (149.5), CK's (3,410) and CK-MB (270.7). Also, the patient's EKG on admission showed ST elevation. A 2-D echocardiogram revealed hypokinesis (50%-55%) with the left anterior descending artery (LAD) wall motion, resulting in a diagnosis of a myocardial infarction (MI). The athlete underwent a cardiac catheterization where a thrombus was detected in the LAD with mild left ventricular systolic dysfunction; this was cleared using an AngioJet device, which left the athlete stable. Hematology was consulted for hypercoaguability workup, and the athlete was found to have heterozygous Factor V Leiden abnormality (evidence of lupus anticoagulant), elevated serum homocysteine level, hypertriglyceridemia, low HDL, elevated LDL, and elevated lipoprotein. The athlete was hospitalized for three days. Following his initial hospital stay, the athlete was placed on anti-coagulants and underwent an exercise Cardiolite at three months after his initial illness, a Multi-Gated Acquisition Scan (MUGA) at five months, and was administered a Holter Test at six months, all of which were without significant abnormalities. Eleven months after the MI, the athlete had his final hematology evaluation and the physician believed the dyslipidemia and homocysteinemia were resolved. The athletic training staff required a second opinion, which concurred that the athlete could return to activity with all appropriate risk factors and symptoms being monitored. The athlete returned to competitive football and remained asymptomatic while under increased care for the remainder of his collegiate career. Presently the athlete is doing well with no complications, but is still on medication for his condition. **Uniqueness:** To our knowledge, there is no other report of a young, elite African-American male athlete having Factor V Lieden and having suffered an anterior ST elevation myocardial infarction. This case was unique to care for due to the lack of standardized management recommendations for athletic trainers. MI's are rare in this age group, especially with no clear etiology, and in an elite athlete who was cleared to continue playing competitive football at the collegiate level. **Conclusions:** To better prepare for MI's in young athletes, athletic trainers should pay careful attention to the patient's personal and family medical histories with an anticipatory mindset in diagnosing anomalies not commonly attributed to this age group. Although return to play guidelines for athletes with an MI should be individualized, it is imperative for athletic trainers to be knowledgeable of the guidelines for athletic participation in order to reduce the risk of arrhythmia-related morbidity or mortality.

Blunt Abdominal Injury In A Collegiate Male Lacrosse Player

Sesma AR, Rooks Y: University of Maryland, College Park, MD

A twenty year-old male Division 1 collegiate lacrosse player was hit in the abdomen by a defensive player at the beginning of practice but continued to play for 90 minutes. He reported to the ATC at the end of practice that he was having rib pain from the hit and some trouble breathing. On field assessment revealed tenderness over the lower left ribs with no rebound tenderness over the abdomen. Rib compression test was painful on the left side. Upon further evaluation in the athletic training room he reported some pain with deep breathing and with forceful expiration. BP and pulse were WNL. Kerr's sign was inconclusive secondary to labral repair surgery on his left shoulder 1 year prior and reporting always feeling "achy" after practice. He was still point tender over the left 8-10th ribs and had some rebound tenderness over the abdomen. Differential Diagnosis: Rib contusion, rib fracture, liver contusion or laceration, spleen laceration or rupture Treatment: He was monitored in the ATR for 30 minutes and symptoms were unchanged. He was allowed to go home and he and his roommates were instructed to call the ATC if his symptoms worsened or if he experienced any nausea, vomiting, dizziness, or increased difficulty breathing. About 1 hour later, his roommates called and said he had been trying to vomit and appeared to be pale. The athlete spoke with the ATC and said he felt extremely nauseous and had increased abdominal pain. He was brought to the ER within 15 minutes. A chest/abdominal x-ray was negative and discharge from the ER was considered, however upon an increase in symptoms an abdominal CT scan was ordered and revealed a grade III laceration of the spleen involving the anterior/inferior aspect with surrounding hemorrhage. He was admitted to the ICU at 1 am. Around 9 am, physicians met to discuss the possibility of removing the spleen but decided to continue to monitor his hemoglobin/hematocrit over 48-72 hours. After 36 hours, he was moved out of the ICU and was discharged after 72 hours with a stable hemodynamic status. The trauma surgeon instructed him to rest completely for 4 weeks with follow-up CT scan at 6 weeks. At 4 weeks he was allowed to start light jogging and lifting. A CT scan at 6 weeks showed ongoing resolution of the hematoma. He was cleared to return to all non-contact activity including stick drills and conditioning. An abdominal ultrasound was performed at 10 weeks post injury, which showed that the hematoma had resolved completely. The athlete was allowed to return to full contact drills and competition with a specialized protective abdominal shirt. He played in his first collegiate game 10 days later and did not have any symptoms for the remainder of the season. Uniqueness: There are no evidence based return-to-play guidelines regarding splenic injuries. A number of case reports show return-to-play in as little as 3 weeks following splenectomy or 8-12 weeks following laceration in football or hockey players but few cases involving lacrosse players. Some literature suggests diagnostic ultrasound may provide a low cost and low radiation alternative to CT for serial monitoring of hematoma resolution. Conclusions: Early recognition of abdominal injuries is vital. They may appear stable but symptoms can worsen in a short amount of time making it imperative to give student-athletes and the people around them detailed instructions. Given the limited information available regarding return-to-play guidelines, decisions must be made on a case-by-case basis with careful collaboration by the sports medicine team. Considerations include equipment modification and appropriate monitoring of signs and symptoms during activity progression.

Blunt Trauma Carotid Artery Injury Resulting In Death In A Collegiate Male Lacrosse Player: A Case Report

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Background: A 19 year old male division III collegiate lacrosse athlete was struck on the left lateral neck with a thrown lacrosse ball during practice. The patient had a whiplash like mechanism when struck and initially complained that his "body went numb" and he fell to the ground in a seated position. He was able to walk off the playing field and into the athletic training room with the help of a teammate. At that time, the patient complained of pain with swallowing, trouble with swallowing, the taste of blood in his mouth, headache, dizziness, nausea, fatigue, neck pain at the site of impact and blurred vision. The patient's neurological status was evaluated and his cervical dermatomes and myotomes were normal at the time of the exam, but the patient complained of intermittent decreased sensation in his right arm and hand. The patient had a past medical history of concussion and post- concussion syndrome, but with no current issues related to this. The patient was becoming increasingly confused as the evaluation continued. The patient presented with concussion-like signs and symptoms. He was not oriented to time and place and had memory deficits, not even being able to recognize his teammates or coach. The patient was sent to the Emergency Room (ER) and initially diagnosed with a concussion and sent home. Within 24 hours, the patient suffered a stroke and was transported back to the ER for further evaluation. The patient was then diagnosed with a carotid artery dissection. He was referred to a trauma hospital where his symptoms progressed to death within one week. Differential Diagnosis: Closed head injury, basilar skull fracture, facial fracture, spinal fracture, seizure, vasovagal syncope, carotid artery injury, subarachnoid hemorrhage, cluster headaches, migraines, horner's syndrome, stroke, syncope, and cervicoephalic arterial dissections. Treatment: Referral to ER by the Certified Athletic Trainer (AT). A computed tomography (CT) scan of the head was performed at the ER and was read as negative. Because of the patient's decreased neurological and mental status, and the normal reading of the head CT scan, a diagnosis of concussion was made. The patient was then released from the ER that same evening. The patient suffered a stroke the following day and was re-admitted. A second CT was performed and showed carotid artery dissection. The cause of the stroke was a blood clot from the dissected area. The patient was taken to a trauma hospital where a stent was inserted to control the swelling. Increased swelling caused brain stem herniation resulting in clinical brain death. The patient was removed from life support five days post injury and died shortly thereafter. Uniqueness: The patient presented with concussion-like signs and symptoms and was initially sent home from the ER diagnosed with a concussion. Within 24 hours, he suffered a stroke resulting from a clot formed from a carotid artery dissection. The patient's symptoms were exacerbated to death within 1 week. Conclusions: A 19 year old male division III lacrosse player presented with concussion-like signs and symptoms after being struck in the neck with a thrown lacrosse ball. Even though proper referral was made in this case, blunt carotid artery injuries can result in death if unrecognized or untreated in a timely manner by further advanced personnel. Diagnosis is often delayed due to a failure to suspect serious injury caused by trauma or a delay in symptom manifestation, especially neurological deficits. Early recognition of the exact mechanism of injury and subsequent symptoms, combined with accurate diagnosis and treatment are the key to patient survival. ATs need to be aware of carotid artery injuries and their severity which can result in death.

Reliability And Validity Of Musculoskeletal Ultrasound For Identification Of Humeroradial Joint Chondral Lesions

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Context: Epicondylalgia is a common condition with pain generating structures including tendon, neural and chondral tissue. Current non-invasive reference standard for identifying chondral lesions is Magnetic Resonance Imaging (MRI). Musculoskeletal Ultrasound (MUS) may be an inexpensive and effective alternative. **Objective**: Examine the reliability and validity of an athletic trainer utilizing MUS for identification of chondral lesions in the humeroradial joint (HRJ). **Design**: Cross-sectional study. **Setting**: Clinical anatomy research laboratory. **Patients or Other Participants**: Twenty-eight embalmed cadavers (mean age=79.5±8.5 years, 14 males). **Intervention(s)**: An athletic trainer with two years of hands-on MUS experience but no formal MUS training performed MUS evaluation of each anterior and distal-posterior capitellum and radial head to identify chondral lesions. The examiner was blinded during analysis of the MUS images. Each elbow was then dissected of all soft tissues and disarticulated for gross macroscopic examination of the articular surfaces of the HRJ. The reference standard was identification of chondral lesions by gross macroscopic examination. A chondral lesion was confirmed and graded by visualization of ulceration or eburnation. **Main Outcome Measure(s)**: Intra-rater reliability for reproducing an image was calculated using intraclass correlation coefficient [ICC (3,k)] for the average of three measurements representing the size of the articular surface of two images representing the same location. Intra-rater reliability was calculated using Cohen's Kappa for the agreement of the presence of chondral lesions on a single image. Validity values were calculated of sensitivity, specificity, positive likelihood ratio (+LR) and negative likelihood ratio (-LR) using the agreement of MUS images and gross macroscopic examination. **Results**: The data indicated high intra-rater reliability for reproducing an image (ICC=0.88 [95% confidence interval {CI}, 0.77, 0.94]) and excellent agreement for evaluating a single image (Kappa=0.93 [95% CI, 0.80, 1.06]). Identification of chondral lesions on all HRJ surfaces with MUS displayed: sensitivity=0.93, specificity=0.28, +LR=1.28 and -LR=0.27. The low specificity and +LR demonstrated that this method may not be ideal for ruling-in a chondral lesion with a positive examination. However, the high sensitivity and low -LR indicated that MUS could accurately rule out HRJ chondral lesions with a negative examination. These values vary with different surfaces and different grades of chondral lesions. Of interest are the sensitivities and -LRs for the radial head (0.94, 0.07), anterior surface of the radial head and capitellum (0.94, 0.18) and grade 4 lesions (1.00, 0.00). This indicates a negative examination with MUS in these areas should provide confidence in ruling out the presence of a chondral lesion. **Conclusions**: Musculoskeletal ultrasound is a reliable and sensitive tool for a clinician to rule out HRJ chondral lesions with relatively little experience and training. These results may assist with clinical assessment and decision-making in patients with lateral epicondylalgia to rule out HRJ chondral lesions.

Blood Flow Of The Brachial Artery: A Bilateral Comparison Among Baseball Pitchers And Position Players

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Context: Vascular pathologies, such as thoracic outlet syndrome and deep vein thrombosis, are of a growing concern among baseball players, particularly pitchers. Adaptive changes to the musculoskeletal system overtime may increase the risk of vascular pathologies and the subsequent time lost from competition. **Objective:** To measure brachial artery blood flow between the dominant and non-dominant arm of professional baseball pitchers and position players. **Design:** Cross-sectional. **Setting:** Professional baseball athletic training room. **Patients or Other Participants:** Twenty-six professional baseball pitchers (Age: 21.0±1.8 years; Height: 172.5±8.3 cm; Weight: 72.6±12.0 kg) and 29 position players (Age: 20.4±1.8 years; Height: 169.1±8.1 cm; Weight: 67.8±11.5 kg) participated. **Interventions:** Pitchers and position players who reported for spring training had their bilateral brachial artery blood flow measured, using diagnostic ultrasound, while in two separate shoulder positions. The first position was at rest with the player's arm by his side. For the second position an investigator passively moved the test shoulder into 90° of abduction, which was monitored with the use of a digital inclinometer, and end range external rotation. This position was chosen due to the similarity to the late cocking phase of the throwing motion. While in each of these positions a second investigator used an ultrasound probe to find the brachial artery, while a third

investigator recorded blood flow volume and peak flow using the ultrasound software. **Main Outcome Measures:** Brachial artery blood flow volume (ml/min) and peak flow (cm/sec) were measured once for each position. Separate 1-way analyses of covariance for blood flow volume and peak flow were conducted. Effect sizes were calculated to provide an indication of clinical meaningfulness **Results:** Pitchers had significantly less blood flow volume (p=0.02, effect size=0.73) and peak flow (p=0.03, effect size=0.78) when in the abducted and externally rotated position of the dominant arm (5.7±0.43 ml/min and 16.8±4.3 cm/sec) compared to the non-dominant arm (7.3±2.2 ml/min and 20.1±4.3 cm/sec). The position players did not have any bilateral difference in blood flow volume (p=0.85, effect size=0.03) or peak flow (p=0.70, effect size=0.11) (8.6±2.9 ml/min and 16.8±4.3 cm/sec for the dominant arm and 8.7±2.9 ml/min and 17.0±4.6 cm/sec for the non-dominant arm). **Conclusions:** Blood flow volume and peak flow in the dominant arm of pitchers was significantly less than the non-dominant arm when placed in passive shoulder abduction and external rotation. Our results suggest that adaptations from pitching may increase the risk of vascular pathologies in the throwing arm. These results may help explain the occurrence of "dead arm syndrome" in pitchers, which has been described as arm fatigue, decreased ball velocity and decreased ball control while throwing. Clinicians should consider incorporating therapeutic exercise and stretching to decrease risk of developing vascular pathologies.

Dominant Vs. Non-Dominant Shoulder And Elbow Range-Of-Motion Differences In Softball Pitchers

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Context: Shoulder and elbow range-of-motion in softball pitchers are not well documented. Side-to-side comparisons of baseball pitchers have demonstrated glenohumeral internal rotation deficits (GIRD) with concurrent increases in external rotation, as well as changes at the elbow. Rehabilitative strategies are typically implemented to prevent related pathology in these athletes. Despite softball pitchers delivering the ball underhand, range-of-motion differences may exist that can drive preventative or rehabilitative treatment decisions for clinicians. **Objective:** Compare dominant and non-dominant passive range of motion (PROM) for shoulder internal rotation (SIR), shoulder external rotation (SER), elbow extension (EEX), and elbow carrying angle (ECA) in softball pitchers. We hypothesized no differences between sides. **Design:** Within-subjects comparison. **Setting:** Climate-controlled biomechanics laboratory. **Patients or Other Participants:** Forty-three female softball pitchers (17.2±2.1 yrs.; 164.7±6.7 cm; 65.6±11.4 kg) were recruited to participate. All subjects were injury free at time of collection. Two pitchers were left-handed. **Interventions:** PROM was assessed using a standard goniometer. SER and SIR were measured supine with the humerus abducted to 90° and the elbow flexed 90°. Start position (0°) was defined as the forearm perpendicular to the table. For both measurements, the humerus was moved passively to the subject's end range-of-motion. End range was determined when the subject's scapula began to aid humeral motion or a firm end-feel was achieved. For EEX, the goniometer was placed with the axis at the lateral epicondyle as the elbow was moved to the subject's extension end range-of-motion. ECA was measured with the subject standing, arms relaxed at side, and axis of the goniometer at the cubital fossa. **Main Outcome Measures:** Three trials were performed for each range-of-motion and averaged to obtain a final value in degrees. Paired t-tests were conducted to compare dominant and non-dominant sides for each measurement. **Results**: At the shoulder, SER demonstrated significance (p<.001) between the dominant (84.5°±7.4°) and non-dominant (78.9°±6.8°) shoulders. SIR was also significantly different (p=.012) between the dominant (71.3°±12.3°) and non-dominant (77.5°±8.9°) sides. At the elbow, ECA was significant (p=.002) between sides (dominant: 8.4°±2.5; non-dominant: 10.3°±2.8°). **Conclusions:** Though softball pitchers are not typically associated with the same pathologies that occur in baseball pitchers, these results suggest that side-to-side differences in shoulder and elbow range-of-motion exist. Unlike baseball, a softball pitcher may play other positions. Further research is necessary to determine if these range-of-motion differences manifest as a result of underhand pitching or the overhand throwing necessary in field positions. Regardless of the source, it is important for clinicians to be cognizant of side-to-side range-of-motion differences in softball pitchers and consider implementing injury prevention strategies as they would with a baseball pitcher.

The Effect Of Intrinsic Musculoskeletal Characteristics On Shoulder Complex Injury In Collegiate Baseball And Softball Players

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Context: Preventable shoulder complex injuries (SCI) are a persistent and principal health concern for collegiate baseball and softball athletes and the clinicians who care for them. Multiple epidemiological studies have been conducted in this population; however, there is a lack of prospective studies examining modifiable musculoskeletal risk factors for SCI. **Objective:** To prospectively identify intrinsic risk factors for SCI in collegiate baseball and softball players. **Design:** Prospective cohort study. **Setting:** Athletic Training Room **Participants:** Data were collected on thirteen collegiate baseball (age:19.7 ±0.9years, height: 72.8± 2.8in, mass:89.2±9.1kg) and ten collegiate softball (age: 19.8± 1.5years, height: 65.1±1.9in, mass:69.8±11.9kg) players. All athletes were cleared for full participation and had no history of shoulder injury in the past month. **Interventions:** All tests were performed preseason. Strength assessments were performed bilaterally using isometric "make tests" (5 seconds) in standard grade 5 manual muscle testing positions using hand-held dynamometry. Muscles tested included: biceps, triceps, glenohumeral internal and external rotators (IR, ER), pectoralis major (upper, lower fibers), trapezius (upper, middle, lower), rhomboids, serratus anterior, and supraspinatus. Range of motion (ROM), flexibility, and postural variables included: glenohumeral IR and ER, pectoralis major flexibility, pectoralis minor length, posterior shoulder tightness (PST), and forward head (FHP) and forward shoulder posture (FSP). The average of three trials was used for analysis. Participants were followed for a single season for SCI as documented and reported by each team's Certified Athletic Trainer. Mann-Whitney U tests were used to compare injured (Inj) and uninjured (NInj) athletes by sport. Statistical significance was set at $p<0.05$ *a priori*. **Main Outcome Measures:** Mean peak force normalized to body weight (%BW) for isometric strength measurements. Mean values in degrees for glenohumeral IR/ER rotation, PST, FHP and FSP. Mean values in millimeters were analyzed for pectoralis minor length. **Results:** Over the season, two baseball players (15%) and five softball players (50%) sustained a SCI, with all injuries except one sustained on the dominant shoulder. No athlete incurred more than one injury. All injuries reported were classified as overuse, with five sustained through a throwing mechanism and two the result of repetitively diving while fielding. No significant differences in strength were demonstrated between Inj and NInj groups in either team. Injured baseball players demonstrated significantly greater bilateral glenohumeral external rotation ROM (dominant ER: Inj=120°±1.9°; NInj=104°±10.7°; p=0.026 and non-dominant ER: Inj=119°±3.7°; NInj=101°±6.6°; p=0.026). However, Inj softball players demonstrated significantly greater dominant PST (Inj=119°±7.9; NInj=105°±4.9; p=0.032) and less non-dominant pectoralis minor length (Inj=59.5mm±3.6mm; NInj=73mm±6.7mm; p=0.008). **Conclusions:** Based on the findings of this study in a small cohort, SCI risk factors may differ between baseball and softball. In addition, flexibility may be a better indicator of SCI risk than strength. Future research should explore if these results can be replicated with large sample size and other populations.

Effect Of A 1-Week Mobilization-With-Movement Intervention On Range Of Motion, Dynamic Balance, And Self-Reported Function In Those With Chronic Ankle Instability

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Context: A single talocrural mobilization-with-movement (MWM) treatment has increased dorsiflexion range of motion (ROM) in individuals with chronic ankle instability (CAI). Examining the effects of multiple MWM treatments on dorsiflexion ROM and other aspects of function would further elucidate the clinical applications of using MWM for CAI rehabilitation. **Objective**: To examine the effects of a one-week talocrural MWM intervention on dorsiflexion ROM, dynamic balance, and self-reported function in adults with CAI. **Design**: Repeated-measures. **Setting**: Laboratory. **Participants**: Eleven adults (5 males, 6 females; age= 20.8±1.2 years; height=179.4±4.9 cm; mass=87.3±14.9 kg) with CAI volunteered to participate. Participants reported a history of at least one ankle sprain, two episodes of the ankle "giving way" in the past three months, and a Cumberland Ankle Instability Tool score of d"25. **Intervention:** The MWM intervention consisted of three treatment sessions performed within one week by the same clinician. The MWM treatment was performed by applying posterior-to-anterior glides of the tibia over the talus with the participant in a kneeling lunge position with the involved limb in a weight-bearing stance. Each treatment consisted of two sets of four glides. Each glide was sustained for 30 seconds at the point of maximal dorsiflexion ROM. **Main Outcome Measures**: Dorsiflexion ROM was measured using the weight-bearing lunge test, dynamic balance was measured using the anterior direction of the Star Excursion Balance Test, and self-reported function was measured using the Foot and Ankle Ability Measure-Sport (FAAM-Sport). These assessments were measured one week before the intervention (baseline), prior to the first treatment (pre-intervention), and 24 hours following the final treatment (post-intervention). Separate one-way ANOVAs examined changes in dorsiflexion ROM (cm), normalized anterior reach distance (%), and the FAAM-Sport (%). The independent variable was time (baseline, pre-intervention, post-intervention). Post-hoc paired t-tests were calculated in the presence of significant time effects. Alpha level was set at pd"0.05 for all analyses. **Results**: No significant time effects were detected for dorsiflexion ROM (baseline: 7.39±2.38, pre-intervention: 7.48±2.54, post-intervention:7.77±2.57; p=0.69) or anterior reach distance (baseline: 71.36±7.88, pre-intervention: 71.55± 7.19, post-intervention:71.54±7.15; p=0.99). A significant time effect was detected for the FAAM-Sport (p=0.01). FAAM-Sport scores were significantly greater post-intervention (86.82±9.18) compared to baseline (77.27±11.09; p=0.01) and pre-intervention (79.82±13.45; p=0.04) but no difference was present between baseline and pre-intervention (p=0.20). **Conclusion**: The one-week talocrural MWM intervention which targeted the posterior noncontractile structures of the ankle did not improve dorsiflexion ROM or dynamic balance in individuals with CAI. However, the MWM intervention did have a positive effect on self-reported function as measured by the FAAM-Sport. Therefore, it appears three treatments of MWM had a positive impact on patient-centered aspects of function but the effects of this intervention on clinical measures of function requires further investigation.

Increasing Ankle Dorsiflexion Range Of Motion Does Not Alter Lower Extremity Kinematics During A Single Leg Squat

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Context: Limited ankle dorsiflexion range of motion (DF ROM) is associated with altered lower extremity kinematics and increased risk of a variety of lower extremity injuries. Interventions to increase DF ROM may alter lower extremity kinematics and ultimately reduce the risk of lower extremity injury in those with limited DF ROM. However, research has not addressed this question. **Objective:** To determine if ankle DF ROM and lower extremity kinematics during a single leg squat are altered following a flexibility intervention in individuals with limited DF ROM. **Design:** Randomized Control Trial **Setting:** Research laboratory. **Patients or Other Participants:** Twenty physically active participants were randomized to the stretching (n=10, 19.40±1.84 years, 171.10±6.89 cm, 72.08±14.34 kg) or control (n=10, 19.50±0.85 years, 171.13±10.46 cm, 68.76±10.86 kg) group. All participants had limited DF ROM, which was defined as DF ROM d"5° (assessed with knee extended). **Interventions:** Goniometric assessments of passive ankle dorsiflexion with the knee extended (DF_{EXT}) and knee flexed (DF_{FLX}) were recorded pre- and post- intervention. In addition, electromagnetic motion-capture recorded lower extremity kinematics on the dominant limb during the single leg squat at both time points. The stretching group performed a single 5-minute session of foam rolling over the triceps surae muscles with the knee extended (2-minutes), triceps surae stretching using a slant board with the knee extended and flexed (2-minutes), and repeated foam rolling (1-minute). The control group sat in a chair for the same duration of time (5-minutes) prior to post-testing. **Main Outcome Measures**: The averages of three trials were used for DF_{EXT} and DF_{FLX} measures. Joint displacements were calculated for sagittal plane ankle and three-dimensional knee and hip joints as the difference between peak joint angles and the joint angles at the initiation of movement. Separate 2x2 (time x group) mixed model, repeated measures ANOVA were performed. Tukey's post-hoc testing was performed to identify location of significance. **Results:** We observed a significant main effect of Time for DF_{FLX} ($F_{(1, 18)}$=19.08, P<0.001, Pre=8.52, Post=9.80) and a significant Time x Group interaction for DF_{EXT} ($F_{(1, 18)}$=7.65, P=0.013, Control: Pre=1.33±2.98, Post=1.93±4.34, Stretching: Pre=1.93±2.23, Post= 4.60±1.93). Post-hoc analysis of the Time x Group interaction for DF_{EXT} indicated the stretching group had significantly greater increases in motion than the control group. No significant main effects or interactions for time or group were observed for any kinematic displacement variables (P>0.05). **Conclusions:** An isolated stretching approach was effective in improving ankle DF ROM in healthy individuals with restrictions, but did not alter lower extremity kinematics during the single leg squat. Implications of these findings suggest isolated acute DF ROM increases do not promote changes in movement patterns. Future research should investigate a longer duration or integrated intervention approach to influence these changes.

Immediate Effects Of A Posterior Talar Joint Mobilization On Spinal-Reflexive And Corticospinal Excitability In Individuals With Chronic Ankle Instability

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Context: Neuromuscular function is altered in people with chronic ankle instability (CAI). One hypothesis is that decreased dorsiflexion, potentially caused by aberrant ankle arthrokinematics from an anteriorly displaced talus, affects neuromuscular control of stabilizing muscles around the ankle. Joint mobilizations are indicated for restoring proper arthrokinematics and restoring range of motion; yet, it remains unknown if mobilization will alter neuromuscular excitability around the ankle. **Objective:** Determine the immediate effects of a grade III posterior talar mobilization on spinal-reflexive and corticospinal excitability in the fibularis longus(FL) and soleus(SOL), as well as ankle dorsiflexion range of motion (DF) in patients with CAI. **Design:** Single-blinded, randomized control trial. **Setting:** Research laboratory. **Patients or Other Participants:** Fourteen participants with CAI were randomized into the mobilization group (11M/3F; 21.3±3.6years; 175.6±7.6 cm; 80.0±13.8kg; FADI:77.6±15.7; FADIs:60.6±17.4) and fifteen participants served as controls (3M/ 12F; 21.1±2.1years; 168.6±8.8cm; 68.9±20.9kg; FADI:82.7±8.4; FADIs: 62.3±17.8). **Interventions:** Following baseline measurements, the mobilization group received 3, 60-second Maitland grade III posterior talar mobilizations from a certified athletic trainer, while the control group sat quietly for 5 minutes. Outcome measures were conducted by a blinded investigator prior to and immediately following the intervention. **Main**

Outcome Measures: Peripheral electrical stimulation of the sciatic nerve was used to elicit Hoffmann reflexes (H-reflex) and maximal muscle responses (M-response) of the fibularis longus and soleus muscles. Spinal-reflexive excitability was defined as the maximum H-reflex normalized to the maximum M-response (H:M ratio). Corticospinal excitability was evaluated by measuring active motor thresholds (AMT) using Transcranial Magnetic Stimulation (TMS). AMTs were determined by finding the lowest TMS intensity that elicited measurable motor evoked potentials (MEPs >100μV) in five out of ten consecutive trials. Active DF range of motion was measured with the patient positioned supine with an inclinometer. Separate 2x2 repeated measures ANOVAs were performed to investigate the differences between groups and time (pre, post) for all outcomes measures. Dependent t-tests were used to evaluate individual group differences over time in the presence of a significant interaction. Alpha level was set *a priori* at $P \leq 0.05$. **Results:** There were no significant differences in spinal-reflexive or corticospinal excitability for either muscle in the mobilization or control group ($P > 0.05$). There was a significant interaction effect for DF ($F_{1,27}=4.10$, $P=0.05$), with the t-test revealing an increase in DF immediately following the joint mobilization (Pre DF:16.4±5.3º, Post DF:19.1±5.6º; t=-2.15, P=0.05) while no difference was found for controls (Pre DF:18.2±5.6º, Post DF:17.8±4.1º; t=0.39, P=0.70). **Conclusions:** A single joint mobilization treatment was efficacious at restoring DF range of motion in participants with CAI, but excitability of spinal-reflexive and corticospinal pathways at the ankle were unaffected. Future research should evaluate the effect of mobilizations over multiple treatment sessions to determine its true neuromuscular therapeutic capabilities.

The Effects Of The Graston Technique® On Knee Extension Angle

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Context: Hamstring dysfunction may increase the likelihood of injury and present with symptoms not associated with the hamstring muscles; interventions designed to lengthen the hamstrings can decrease likelihood of injury and resolve many associated symptoms. **Objective:** To evaluate the effects of an instrument assisted soft tissue mobilization technique on knee extension angle. **Design:** Cohort study. **Setting:** Research laboratory. **Patients or Other Participants:** 32 physically active males with limited hamstring flexibility (21.6±2.2yo; 1.8 ± 0.7m; 80.8±11.6kg) volunteered to participate in this study. Participants had no acute lower extremity injury in the last 12 months, no current low back pain, no history of diabetes, and were not taking anticoagulant medication. **Interventions:** All participants were pre-tested using the passive knee extension test. To conduct this test, subjects were asked to lay supine, flex the hip to 90p and allow a standardized weight to slowly extend the knee. A digital inclinometer (ACUMAR Datacapture 5.0 Digital Inclinometer, Lafayette Instrument Co., Lafayette, IN) was placed on the shaft of the tibia to record maximal knee extension angle. Three trials were completed. Instrument assisted soft tissue mobilization treatment was employed using the Graston Technique® (GT). This technique utilizes stainless steel instruments to assess and treat soft tissue adhesions. A standard GT protocol was followed, which included an active warm-up, soft tissue mobilization using the instruments, low load high repetition exercises, and stretching. Participants were randomly assigned to one of three treatment groups: Global Graston Technique(G-GT), Local Graston Technique(L-GT), and a control group. The G-GT group received the standard GT protocol with specific mobilization over the posterior thigh, leg, and plantar surface of the foot. The L-GT group received the standard GT protocol with specific mobilization only over the posterior thigh. The control group received a 15-minute sham electrical stimulation treatment. For each group, treatment occurred on four separate days with a minimum of 48 hours between treatments. Post-testing occurred in the same manner as the pre-test at the end of the four treatment sessions. A RMANOVA was calculated to determine differences between the groups. Tukey post hoc tests were completed on any significant findings. Alpha level was set at $P<.05$. **Main Outcome Measures:** Knee Extension Angle(°). **Results:** A significant test by group interaction was identified ($F_{(2,21)}=4.16$, $p=0.01$). Specifically, the G-GT group had improved range of motion following treatment (pretest =156.3°±10.7°, posttest= 163.0°± 11.0°, mean difference=6.8°), however, neither the L-GT group (pretest=156.8°±7.0°, posttest= 160.6°±10.0°, mean difference=3.8°) or the control group (pretest =155.5°±9.6°, posttest= 154.5°± 13.8°, mean difference=1.0°) resulted in significant improvements. **Conclusions:** The use of the Graston Technique® can improve knee extension angle when the treatment area includes the entire posterior thigh, leg, and plantar surface of the foot. This evidence may support the current concepts of fascial slings suggested by Thomas Myers.

Comparing Interventions For Delayed Onset Muscle Soreness In College Aged Subjects: Nintendo® Wii Boxing, Ice And Light Concentric Exercise

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Context: Delayed-onset muscle soreness (DOMS) induced by eccentric exercise occurs in athletes and causes discomfort and potentially a decline in physical performance or loss of practice time. Modalities such as ice and massage exist to combat this discomfort and pain, but outcomes vary in effectiveness. Active gaming has become a trendy rehabilitation tool in athletic training facilities; however, no studies have investigated whether active gaming for sore muscles is superior to commonly used treatments for DOMS. **Objective**: The purpose of this study was to compare the effectiveness of active gaming, specifically Wii boxing, compared to standardized light concentric exercise, and ice bag treatment in alleviating DOMS. **Design**: Randomized-controlled trial. **Setting**: Controlled research laboratory. **Patients or Other Participants**: Twenty-eight college-aged volunteers (19.52 ±0.79yrs). **Interventions**: Participants performed an eccentric exercise protocol of the non-dominant elbow flexors to induce DOMS. Participants were randomized into one of four conditions: Wii Boxing (*n*=7), light concentric exercise (LCE; *n*=8) consisting of elbow flexion and extension with minimal weight resistance, ice bag treatment (*n*=5), or control group (natural history; *n*=8). On follow-up Days 1 and 2, participants completed 20 minutes of their selected intervention. **Main Outcome Measures**: Measurements were taken on Day 0 prior to DOMS and pre and post intervention on Day 1 and 2: total active (TA) ROM during elbow flexion and extension, pain using the Brief Pain Inventory (BPI: scale 1-10), muscle tenderness using pressure pain thresholds (PPTs), and functional disability (QuickDASH). Change scores (post-pre) were created for each measure and analyzed with between-subjects 1-way ANOVAs. **Results**: On Day 1, the Wii group [*M*=1.52°(*SE*=.83); 95% confidence intervals (*CI*): -0.25,3.29] exhibited improvements in TA ROM during elbow flexion compared to the LCE [*p*=.021; *M*=-1.23°(*SE*=.73); 95% *CI*: -2.75,0.29] and control group [*p*=.008; *M*=-1.47°(*SE*=.73); 95%*CI*: -2.99, 0.56]. On Day 2, the ice group [*M*=-9.09(*SE*=4.31); 95%*CI*: -21.06,2.88] reported improvements in functional disability compared to the Wii [*p*=.011; *M*=1.29(*SE*=2.15); 95%*CI*: -3.97,6.56], LCE [*p*=.021; *M*= 0.16(*SE*=0.80); 95%*CI*: -1.79,2.12] and control group [*p*=.012; *M*=0.85(*SE*=2.46); 95%*CI*: -4.97, 6.68]. On Day 2, the ice group [*M*=-1.2(*SE*=.58); 95% *CI*: -2.82,0.42] reported greater reductions in pain compared to the Wii [*p*=.021; *M*=0.43(*SE*=0.37); 95%*CI*: -0.47, 1.33], LCE [*p*=.008; *M*=0.71 (*SE*=0.61); 95%*CI*: -0.77,2.20] and control group [*p*=.049; *M*=0.13 (*SE*=0.13); 95%*CI*: -0.17,0.42]. Also on Day 2, the ice group [*M*= 0.72(*SE*=.12); 95% *CI*: 0.44, 1.00] exhibited reduced muscle tenderness compared to the Wii [*p*=.004; *M*=-.02(*SE*=0.10); 95%*CI*: -0.33,0.30], LCE [*p*<.001; *M*=-0.25(*SE*=0.15); 95%*CI*: -0.62,0.12] and control group [*p*=.002; *M*=-0.09(*SE*=0.19); 95%*CI*: -0.56,0.39]. **Conclusions**: These results suggest that light exercise using Wii Boxing temporarily improves ROM following an induced bout of DOMS. However, ice bag treatment was superior in improving pain, functional disability, and muscle tenderness compared to all other conditions. Clinically, this suggests a multiple intervention strategy to rehabilitation should be used for optimal outcomes.

Better Together Or Apart: Effects Of Simultaneous And Individual Application Of Therapeutic Cold & ESTIM On Pain Perception

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Context: The therapeutic effects of cold modalities and electrical stimulation (ESTIM) as individual treatments in the management of musculoskeletal injury are well documented in the research literature and commonplace practice in the clinical setting. Although the simultaneous application of both modalities is empirically accepted and practiced, the effects of these treatments have not been demonstrated in the research literature. Objective: The purpose of this study was to examine if these therapeutic modalities are more effective when applied simultaneously or singularly in the treatment of pain. Design: Crossover study. Setting: Research laboratory. Patients or Other Participants: 21 participants (9 males, 12 females) (mean: age = 22.3 ±2.8 years; height = 171.5 ±9.6 cm; mass = 68.5 ±13.6 kg) with no history of current or recent musculoskeletal injury. Interventions: Independent variable was treatment mode: cold pack (CP), electrical stimulation (IFS), and electrical stimulation/cold pack (IC). Operational definitions: IFS (interferential stimulation: carrier frequency 4000 Hz, beat frequency 80/150 Hz) (Intelect Legend XT, Chattanooga Group, Vista, CA), CP (Moji, Glenview, IL). A repeated measures design was utilized, each participant completed three treatment sessions over a three-day period. The order of treatment mode was randomized for each participant. A modified pneumatic tourniquet was used to induce perceived pain during each session. A baseline pain threshold was established at a pressure level (mmHg) at which each subject indicated a perceived pain rating of "6" on a Visual Analog Scale (VAS). VAS was used to assess pain level at various time periods over a twenty-minute treatment application and twenty-minute post-application. Main Outcome Measures: Dependent variable was VAS score (mm). Separate repeated measures ANOVA was used to assess differences between treatment mode on VAS score at various time points (minute 0, 6, 10, 20, 26, 40). The level was set a priori at .05, interactions were analyzed using post-hoc testing. Results: All values presented as mean ±SD (mm). Analysis revealed no differences between treatment mode at any given time period: minute 0 (P = .81), CP (54.23 ±6.8), IFS (53.42 ±8.4), IC (54.52 ±9.4); minute 6 (P = .08), CP (46.05 ±16.1), IFS (51.71 ±18.9), IC (42.19 ±16.8); minute 10 (P = .06), CP (45.23 ±20.7), IFS (48.95 ±18.8), IC (39.28 ±19.1); minute 20 (P = .18), CP (42.47 ±24.4), IFS (43.23 ±20.7), IC (36.28 ±24.6); minute 26 (P = .41), CP (45.33 ±24.7), IFS (45.33 ±23.2), IC (41.28 ±23.3); minute 40 (P = .21), CP (50.66 ±23.6), IFS (49.0 ±26.2), IC (45.33 ±26.4). Conclusions: Our results indicate the simultaneous application of ESTIM and cold modality does not provide better pain relief than separate applications. The clinical practice of combined modalities application should be revisited for considerations of evidence-based practice and effective resource management.

Cryotherapy Does Not Alter Passive Dorsiflexion Range Of Motion And Plantarflexor Musculotendinous Stiffness

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Context: Cryotherapy is commonly used in health care. Its influences on tissue extensibility, elasticity, and joint range of motion (ROM), however, are not well understood. **Objective:** The purpose of the study was to determine if a 20-minute crushed ice bag application to the plantarflexor muscle group influenced passive ankle dorsiflexion ROM, passive plantarflexor torque (PPT), and passive musculotendinous stiffness (MTS) at 4 joint angles ($\tilde{}_{1,2,3,\&4}$). **Design:** Randomized controlled study. **Setting:** Controlled laboratory setting. **Participants:** Twenty recreationally active college-aged participants (male: n=9, age= 21.63±2.00yrs, ht=178.31±6.72cm, mass=78.54±32.89kg; and female: n=11, age=19.5±0.52yrs, ht= 166.46 ±9.41cm, mass= 67.58± 8.31kg) with no known lower extremity injuries in the 6 months prior to data collection volunteered. **Interventions:** A 2x2x2x5 cross-over measure was conducted on all factors. Independent variables were treatment (a 2-kg crushed ice bag or nothing), gender (male and female), day (1st and 2nd), and time (pre-treatment, immediate post-, 10, 20, & 30 minutes post-treatment). Subjects were randomly assigned to a treatment order after signing the IRB approved informed consent. On the first day, we obtained subject demographics and conducted the familiarization session. On the second and third day, subjects warmed up on a stationary cycle for 5 minutes. Subjects were then positioned on the chair of an isokinetic dynamometer for passive ankle dorsiflexion and passive torque measures. Passive dorsiflexion measures were taken twice at 5°/s, starting at 20° of plantarflexion. The

pre-determined treatment was then applied for 20 minutes. Post-treatment measures were taken immediately and at 10, 20, and 30 minutes after both treatments. Passive MTS was examined based on passive angle-torque curves. We also measured surface interface temperature every minute in pre-, during, and post-treatment measures. **Main Outcome Measures:** We assessed maximum passive ankle dorsiflexion ROM, maximum PPT, and passive MTS at 4 joint angles ($\tilde{}_{1-4}$) separated by 5° on 5 different time and 2 different days. **Results:** As expected, cryotherapy decreased surface temperature at each post-treatment measure (Pre: 29.68± 1.10°C, Post: 8.52±3.37°C, 10_{post}: 21.02±1.57°C, 20_{post}: 23.25± 1.84°C, and 30_{post}: 24.21± 1.50°C; Tukey-Kramer, $P<.01$). Control group and ambient air temperature fluctuated less than 2°C. Cryotherapy did not influence ROM (Ice_{male}: 33.89±4.55°, $Control_{male}$: 32.60±5.20°, Ice_{female}: 32.36±10.86°, $Control_{female}$: 33.35± 9.91°; Tukey-Kramer, $P>.85$). There was no main effect difference between times for ROM, PPT, or MTS for each treatment (Tukey-Kramer, $P>.05$). Males, however, had higher PPT (Ice: 76.91±20.28Nm, Control: 74.01± 15.42Nm; $F_{1,360}=718.72$, $P<.01$) compared to female PPT (Ice: 26.46±10.18Nm, Control: 30.46± 12.92Nm). This was also true at each of the $MTS\tilde{}_{1-4}$ (Tukey-Kramer, $P<.05$). **Conclusions:** Decreasing plantarflexion temperature with a 20-minute crushed ice bag does not appear to influence passive ankle dorsiflexion ROM, maximum PPT, or passive MTS. Regardless of cryotherapy application, males had greater passive PPT and MTS than female.

Effect Of Different Compositions Of Ice Bags On Circulation In The Femoral Artery In Healthy Males

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Context: Many studies have investigated the effectiveness of different cryotherapy agents, including different compositions of ice bags, in lowering tissue temperatures. However, there is no current research that has investigated the effect of ice bag composition on blood flow velocity. **Objective**: To investigate different compositions of ice bags on blood flow velocity in the femoral artery. **Design**: A repeated-measures counterbalanced design. **Setting**: University Laboratory Setting. **Patients or Other Participants**: Male subjects 18 to 35 years old were recruited on a volunteer basis from the surrounding area. Fifteen healthy male participants (age = 20.3 ± 1.2 years, height = 181.3 ± 7.9 cm, mass = 75.3 ± 13.9 kg) with no circulatory conditions or current lower extremity injuries completed the study. **Interventions**: Ice bags made with crushed, cubed, wet crushed, or wet cubed ice were prepared with standardized procedures and applied to the right upper thigh for 15 minutes. The wet bag composition simulated melting that often occurs clinically prior to application. The ice composition selection was randomly assigned and administered on four separate test sessions, with at least 24 hours in between sessions. The blood flow (cm/sec) was measured via spectral Doppler ultrasonography (SonoSite M-Turbo, SonoSite, Inc., Bothell, WA). **Main Outcome Measures**: Blood flow velocity of the right femoral artery was measured prior to ice application and every 5 minutes for 30 minutes following treatment removal. A mixed design repeated measure analysis of variance (ANOVA) compared blood velocity between the different ice bag compositions across the time points. Four separate repeated measures ANOVA's were performed testing each individual ice bag composition's effect on blood flow in relation to time elapsed. **Results**: Among the four different types of ice bag compositions there was not any significant difference in blood flow velocity (P = .63). Individually, there was no significant difference in blood velocity over the eight time points for the wet crushed (57.9 to 62.67 cm/sec, P = 0.66), cubed (60.4 to 59.9 cm/sec, P = 0.72), and wet cubed ice bags (65.1 to 63.0 cm/sec, P = 0.64). However, there was a significant decrease in blood velocity (74.2 to 62.8 cm/sec) relative to time with the crushed ice bag (P = .006) and pairwise comparison revealed the significant difference between pre-application baseline and all post ice application velocities. This significant difference was attributed to the average pretreatment blood flow velocity for this group being significantly different from the other three. **Conclusions**: Ice bag composition and the influence of a melted ice state do not affect blood flow velocity and are an equally effective application of cryotherapy to be used clinically.

Modalities Evidence-Based Forum

Wednesday, June 26, 2013, 10:30AM-11:30AM; Palm D; Moderators:

Effect Of Lace-Up Ankle Braces On Electromyography Measures During Walking In Subjects With Chronic Ankle Instability

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Context: Injuries to the ankle are one of the most common musculoskeletal injuries in athletics with a high rate of recurrence and prolonged dysfunction. Previous studies have shown a reduction in ankle sprains among those with previous ankle injury while braced, however, ankle braces have not been shown to decrease the severity of injury, It may thus be implie that the mechanism by which a brace decreases injury risk goes beyond restricting range of motion and may also affect the neuromuscular control of the ankle. **Objective:** To determine the effect of a lace-up ankle brace on lower extremity muscle function in subjects with chronic ankle instability (CAI). **Design:** Crossover. **Setting:** Laboratory. **Patients or Other Participants:** Fifteen adults with CAI (height=173±11cm, mass=72±14kg, age=23±4, sex=M:5 F:10) participated. **Intervention(s):** Condition order was randomly allocated to condition order (lace-up brace or no brace). Surface EMG electrodes were placed over the anterior tibialis (AT), peroneus longus (PL), lateral gastrocnemius (LG), rectus femoris (RF), biceps femoris (BF) and gluteus medius (GM). The protocol consisted of 30 seconds of treadmill walking at 3 mph during each condition. **Main Outcome Measures:** Normalized EMG amplitude 100ms pre- and 200ms post initial contact, time of activation relative to initial contact, and percent of activation across the stride cycle were calculated for each muscle across 9 steps. Muscle activation was determined for each muscle if the amplitude was 10 SD over the mean amplitude during quiet standing. A negative value for time of onset represents muscle activation prior to initial contact. Percent of activation was calculated as the proportion of the total time across the stride cycle that the amplitude was greater than the previously described threshold. Paired t-tests were performed for each dependent variable to compare groups. The level of significance was set a priori at Pd"0.05 for all analyses. **Results:** The pre-contact amplitude of the PL was significantly lower in the braced condition (0.16±0.08) when compared to the shod condition (0.20±0.10mV, p=0.01). The AT, PL, RF, and GM were activated significantly later relative to contact in the braced condition when compared to the shod condition (AT: -0.32±0.02 vs. -0.36±0.16ms, p=0.02; PL: 0.02±0.12 vs. -0.07±0.10ms, p=0.02; RF: -0.07±0.06 vs. -0.14± 0.15ms, p=0.03; GM: 050±.082 vs. -0.08±0.10ms, p=0.009, respectively). The PL and RF were activated for a significantly shorter percentage across the stride cycle in the braced condition when compared to the shod condition (PL: 28.67±9.35 vs. 36.04±10.26%, p=0.002; RF: 30.79±18.86 vs. 36.90±24.52%, p=0.05, respectively). **Conclusions:** Lace-up ankle braces caused an alteration in lower extremity muscle activation in individuals with CAI. These alteration in muscle activation due to bracing may contribute to the decrease the recurrence of ankle sprains in people with CAI by providing a more efficient muscle activation patterns.

Effect Of Over-The-Counter Foot Orthotic Devices On Multi-Segment Foot Biomechanics

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Context: Over-the-counter (OTC) foot orthoses are thought to be a cost-effective alternative to custom-made devices. However, few studies have compared OTC devices and most biomechanical research involving orthoses has focused on rearfoot biomechanics. **Objective:** To determine changes in multi-segment foot biomechanics during shod walking in three commercially available OTC devices: SOLE, SuperFeet (SF), and Powerstep (PS) compared to no orthotic (NO). Based on a previous SOLE study, and construction of the OTCs, we hypothesized significantly reduced plantar fascia strain (PFS) for SOLE and SF compared to NO. We also hypothesized that SF and PF would significantly reduce rearfoot eversion (RFEV), tibial internal rotation (ROT), and medial longitudinal arch deformation (MLAD) compared to NO. **Design:** Crossover, repeated measures. **Setting:** Clinical research laboratory. **Patients or Other Participants:** Eleven healthy individuals (3 males, 8 females: age= 31.3 ±6.7yrs, height= 167.5±8.4cm, mass= 65.1±12.8kg) volunteered through informed consent. **Interventions:** Retroreflective markers were placed on the right limb to represent forefoot, midfoot, rearfoot and shank segments. 3D kinematics were recorded using 8-cameras (Vicon, Oxford, UK: 120Hz) placed around a treadmill while subjects walked in a neutral shoe at 1.1 m/s. The order of the 4 conditions was randomized. **Main Outcome Measures:** 3D marker trajectories were calculated using custom-written

Matlab software (Natick, USA). RFEV, MLAD, and ROT were measured in degrees. PFS (unitless) is calculated by approximating the plantar fascia spanning between the first metatarsal head and calcaneus and determined as change in relative marker position. Between-condition differences were determined using 1 (group) x 4 (condition) repeated measures ANOVAs and a priori post-hoc testing ($P \leq 0.05$). **Results:** There were no significant differences in peak RFEV for any OTC (SOLE: $F_{1,7}=2.11$; 10.60±4.63deg; $P=0.11$, SF: $F_{1,7}=3.01$; 10.10±5.64deg; $P=0.09$, PS: $F_{1,7}=1.87$; 11.72±5.30deg; $P=0.24$) compared to NO (13.31 ±5.19deg). There were no significant differences in peak ROT for any OTC (SOLE: $F_{1,7}=0.99$; 0.28±7.37deg; $P=0.42$, SF: $F_{1,7}=1.79$; -1.26± 5.14 deg; $P=0.29$, PS: $F_{1,7}=1.81$; -1.67 ±5.76deg; $P=0.24$) compared to NO (-0.21±3.43deg). There were no significant differences in peak MLAD for any OTC (SOLE: $F_{1,7}=0.97$; 155.55±7.46deg; $P=0.41$, SF: $F_{1,7}=1.01$; 158.04±8.25deg; $P=0.30$, PS: $F_{1,7}=0.99$; 154.88±7.47deg; $P=0.33$) compared to NO (156.25 ±7.03deg). There were no significant differences in PFS for PS ($F_{1,7}=1.78$; 0.008±0.004; $P=0.29$) compared to NO (0.009±0.001). Significant decreases in PFS were measured for SOLE ($F_{1,7}=7.65$; 0.001±0.009; $P=0.02$) and SF ($F_{1,7}=3.55$; 0.004±0.007; $P=0.05$) compared to NO. **Conclusions:** Supporting the hypotheses, a SOLE OTC orthotic does not control RFEV or MLAD but does reduce PFS compared to walking without an orthotic device. Partially supporting the hypotheses, SF also reduces PFS. Contrary to the hypotheses, PS and SF do not control rearfoot or tibial kinematics nor reduce MLAD. SOLE and Powerstep donated their devices. Funded by SOLE and Alberta Innovates: Health Solutions.

Effect Of Prophylactic Ankle Support On Actual And Perceived Dynamic Balance

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Context: Ankle injuries are the most common injury associated with sports participation. Taping and bracing are commonly used measures to prevent ankle injury. Patients often report a feeling of increased stability due to Prophylactic Ankle Support, however previous studies have produced conflicting results. **Objective:** The purpose of this study was to examine the actual and perceived effect of taping and bracing on dynamic stability. **Design:** Repeated measures design. **Setting:** Controlled laboratory setting. **Patients or Other Participants:** 21 physically active subjects [12 females (age = 20.33 ± 1.44 years, height = 165 ± 0.05 cm, mass = 68.76 ± 12.69 kg), and 9 males (age = 21.33 ± 1.66 years, height = 180 ± 0.10 cm, mass = 86.54 ± 9.46 kg)]. **Interventions:** Dynamic stability and perception of stability were assessed barefoot and with the ankle taped and braced. The taped ankle condition used a standard preventive tape application including two anchors, three stirrups, close downs, horseshoes, two heel locks per side and two figures' of eight. During the braced condition, participants were fitted with a Swede-O Inner Lok 8 ankle brace per manufacturer guidelines. **Main Outcome Measures:** The Biodex Balance System SD was used to measure medial-lateral and anterior-posterior stability. Dynamic balance was assessed in a single leg stance during three 20-second trials at stability level 4. A 30 second rest period was provided between trials. Perception of stability was assessed using a 4-point Likert scale (1 = very unstable, 2 = unstable, 3 = stable, 4 = very stable) after each test session. Independent variables were counter-balanced to minimize the effects of fatigue associated with the testing procedures. A Repeated measures ANOVA was used to analyze the difference between barefoot, ankle tape, and ankle brace for medial-lateral and anterior-posterior dynamic stability indices and perception of stability. All tests of significance were carried out at an alpha level = 0.05. The Bonferroni post hoc test was used for all paired comparisons. **Results:** Significant differences were not found for medial-lateral stability (Barefoot = 1.24 ± 0.63, Taped = 1.21 ± 0.72, Braced = 1.38 ± 0.71) nor anterior-posterior stability (Barefoot = 1.70 ± 1.07, Taped = 1.50 ± 0.89, Braced = 1.47 ± 0.74). Significant differences were found for perception of stability (Barefoot = 2.57 ± 0.60, Taped = 3.32 ± 0.67, Braced = 2.90 ± 0.76; p = 0.000). The taped condition was significantly different from both barefoot and braced conditions (p = 0.000 and p = 0.021 respectively). **Conclusions:** The use of ankle taping and bracing had no influence on dynamic stability measures in this study. Ankle taping did cause an increased perception of stability suggesting that ankle taping may have more of a placebo effect in uninjured ankles.

Plantar Flexion Motion Allowed By Different Ankle Taping Combinations Assessed By The Taguchi Method

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Context: There are many taping techniques used by athletic trainers, but it is yet unknown if one taping technique is better than another. Taping technique can be broken down into components and these components can be systematically varied (i.e., one or three layers thick of tape) and studied for effectiveness. No ankle taping studies have systematically explored systematic optimization of tapping techniques. **Objective**: To determine the optimal ankle taping combination for reducing plantar flexion using the Taguchi Method (TM) model. **Design**: A repeated measures design was used where each participant was tested in each of the four ankle taping combinations. **Setting**: Research laboratory. **Patients or Other Participants**: Thirty-five female participants (aged=24.7±4.91 years; 160.17±11.93 cm; 61.62±5.83 kg) with no ankle injury in the past year volunteered for this study. **Interventions**: Ankle taping factors Weight (W), Tape Height (H) and pre-wrap Thickness (T) were systematically varied. Each parameter had two levels: W1 = one tape layer thick; W2 = three tape layers thick; H1 = 20% of fibular height; H2 = 35% of fibular height; T1 = one pre-wrap layer thick; T2 = three pre-wrap layers thick. 2" Crammer Underwrap™ and 1.5" Coach™ athletic tape was applied down to the middle of the arch using a predefined technique. Taping combination order was randomized for each participant. The Inman ankle machine, with an attached wireless inclinometer, was used to measure plantar flexion and has been found reliable and valid in previous studies. **Main Outcome Measures**: A one way ANOVA was used to analyze the degrees of plantar flexion allowed by select ankle taping combinations which were selected using a TM orthogonal array 4. Alpha was set at <0.05. Using TM procedures low contributing factors were pooled to become error variance and ANOVA was rerun. The optimal combination was determined based on the signal to noise ratio (S/N) Smaller is Better, and then confirmed with collected data. **Results**: In the traditional means analysis W ($F_{1,136}$ = 23.36; p=0.001), H ($F_{1,136}$ = 6.61; p=0.01) were found to be significance, but T ($F_{1,136}$ = 0.94; p=0.33) was not. In the initial S/N ratio analysis W accounted for 74.45%, H 20.70% and T 5.85% of the variance. After T was pooled error variance accounted for 5.85%, W 73.45% and Height 20.70% of the variance. The optimal combination (W2-H2) estimation was 40.11 ± 11.77 º of allowed plantar flexion. Confirmatory analysis on n=35 participants shows the average results for all combinations containing W2-H2 was 40.97 º which is within the 95% CI. **Conclusions**: The results provide evidence of the optimal ankle taping combinations for limiting ankle plantar flexion. Further research is needed to determine what effect exercise has on the various combinations used in this study.

The Effects Of Load Range And Brace Support In Ankle Complex Stability

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Context: Stabilization against an inversion injury is a major function of an ankle brace. No comprehensive analysis concerning the effectiveness of brace support on ankle-complex behavior across a load range has been reported. **Objective:** To evaluate the effect of different types of brace support on ankle-complex inversion rotation and stiffness. **Design:** Cross-sectional. **Setting:** Research laboratory. **Participants:** The dominant ankle of 22 female collegiate athletes (20.7±1.2 years, 70.2±8.7 kg, 173.2±9.0 cm). **Interventions:** Maximal inversion load-displacement curves were collected using a six degrees-of-freedom linkage-instrumented ankle arthrometer. With the subject wearing her own low-top athletic shoe all ankles underwent loading at 15° plantar-flexion (PF), which was defined as the zero-load/zero-moment unloaded position. **Main Outcome Measurements:** Inversion ROM was measured from zero to 4-Nm with the loading portion of the moment-angular displacement curve divided into low-load (0-2 Nm) and high-load (2-4 Nm) segments. Rotation was measured and secant stiffness for each load-range calculated. Repeated measure ANOVA was used to compare rotation values among the no brace and braced ankles (soft-shell [Zoom™]; lace-up [ASO™]; rigid [Active Ankle T2™]) at 4-Nm. Separate t-tests compared differences in rotation and stiffness between low-load and high-load ranges. Significance was set a priori at $P < .05$. **Results:** At the 4-Nm load, bracing (soft-shell: 21.5±4.9°; rigid: 22.3±6.7°; lace-up 24.5±7.6°) produced a significant reduction in ROM when compared to the no brace

trial (47.1±9.7°; *P*<.001), with no ROM differences between braced conditions (*P*>.05). Across the two load ranges, bracing restricted ROM more in the 0-2 Nm load range than in the 2-4 Nm load range [soft-shell (8.7±2.7°,12.8±3.0°; *P*<.001), rigid (8.1±3.5°,14.2±3.9°; *P*<.001), lace-up (9.6±4.5°,14.9±3.9°; *P*<.001). Whereas, in the NB condition, greater ROM occurred between the 0-2 Nm load range than in the 2-4 Nm load range (33.0±9.1°,14.1±2.2°, *P*<.001). Bracing produced greater stiffness in the 0-2 Nm load range than in the 2-4 Nm load range [soft-shell (.259±.11 Nm/°, .165±.04 Nm/°; *P*<.001), rigid (.303±.16 Nm/°, .151±.04 Nm/°; *P*<.001), lace-up (.299±.22 Nm/°, .145±.05 Nm/°; *P*=.001). Whereas, in the NB condition, less inversion stiffness was found in the 0-2 Nm load range (.066±.02 Nm/°) than the 2-4 Nm load range .145±.02 Nm/°, *P*<.001). **Conclusions:** The braces we tested lead to a significant reduction in maximal inversion rotation. The largest effects of the braces on inversion ROM of the ankle complex occurred in the low-load range. The relative contribution of the brace to total stiffness in this region was high. However, towards the extremes of motion, the ankle becomes greatly stiffer than in its neutral zone. Therefore, the relative contribution of the brace to the total stiffness in this region is diminished. Objective information on the amount and nature of passive support may assist athletic trainers when recommending braces to their patients.

Ankle Bracing Enhances Mediolateral Postural Stability In Those With And Without A History Of Ankle Sprains

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Context: Ankle braces have been shown to reduce the risk of both first-time and recurrent sprains. Since deficits in postural stability have been linked to an underlying mechanism for increased ankle sprain risk, it is theorized that the effectiveness of ankle braces in reducing ankle sprain risk is attributed to its ability to improve postural stability. However, the effects of ankle bracing on postural stability have been inconclusive, especially in those with a history of ankle sprain. Time to boundary (TTB) is a relatively new method to assess spatiotemporal postural stability. Assessing balance performance using TTB may elucidate the effects of ankle braces on postural stability. **Objective**: To examine the effects of ankle bracing on single limb balance in individuals with and without a history of ankle sprain using TTB measures. **Design**: Matched crossover design. **Setting**: Research laboratory. **Patients or Other Participants**: Nineteen individuals with a history of ankle sprain (AS) (20.4±1.9yrs, 170.2±7.0cm, 74.7±13.6kg), and 19 age-, height-, and gender-matched control subjects (20.8±2.0yrs, 169.5±6.4cm, 75.6±15.9 kg) participated. **Interventions:** Each participant attended two testing sessions. Balance was assessed while wearing an ASO® brace in one session and without brace in the other. The order of testing was counterbalanced within each group. All participants performed 3 10-second trials of single-leg balance on their affected limb with eyes closed. **Main Outcome Measures**: TTB in anterior-posterior (AP) and medial-lateral (ML) directions were calculated based on the center of pressure position and velocity in relation to the boundaries of the foot. The mean and standard deviation of TTBML and TTBAP were compared using separate group (AS/control) by condition (brace/no-brace) mixed-model ANOVAs. Alpha level was set a priori at p<0.05. **Results**: There were no significant group by condition interactions for any TTB variables. There were significant condition main effects in which all participants exhibited significantly increased mean TTBML (mean difference=0.29±0.74, 95%CI: 0.04-0.53, p=0.02), and standard deviation of TTBML (mean difference =0.51±1.16, 95%CI: 0.12-0.89, p=0.01) during the braced condition, regardless of group. No significant group main effects were found for any of the TTB measures. **Conclusions**: The increased mean TTBML in the braced condition reflects an improved ability to maintain single limb balance. An increase in the TTBML standard deviation reflects a less constrained sensorimotor system and an enhanced ability to adapt to ML balance perturbations. These improvements can potentially be attributed to enhanced mechanical support in the mediolateral direction as well as augmented proprioceptive feedback from cutaneous mechanoreceptors while wearing the brace. Therefore, regardless of a history of ankle sprain, use of an ankle brace has a potential to improve balance performance. This may be one of the underlying mechanisms for the prophylactic benefit of ankle bracing for new and/or recurring ankle injuries.

Osteochondral Lesion Of The Elbow Trochlea In Collegiate Basketball Player

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Background: A 19yo Division I collegiate basketball point guard presented with a 4 month history of increasing elbow pain during the competitive season. Pain was insidious in nature and occurred with forced terminal extension involving the right-dominate shooting arm. Outside of basketball, pain occurred during weight lifting while loaded in elbow flexion > 90 degrees (e.g. bench press, hang cleans) as well as with heavy single arm rows. Examination demonstrated loss of terminal elbow extension with reproducible pain along the posterolateral joint line. Tenderness and pocket effusion were evident over the same region. The athlete described an occasional "catching" sensation. There was no visual deformity or incongruence of anatomical landmarks. The cubital carrying angle was normal for a male and there was no previous elbow, nor shoulder, trauma. Collateral ligamentous tests were negative. Neurological screen was normal. Within the first month of pain presentation, the athlete was evaluated by the team orthopedist. Although an osteochondral injury was suspected, xrays taken at the time were unremarkable. After educating the athlete about the suspected injury, he decided to treat conservatively and re-evaluate after the season. During the 4 months of conservative treatment, attempts to manage symptoms were made with modalities and weight room modifications. **Differential Diagnosis:** Valgus Extension Overload Syndrome, Posterolateral Rotatary Instability, Olecranon Stress Fracture, Triceps Tendonitis, Ostechondral lesion. **Treatment:** Athlete was referred back to the team orthopedist for follow up evaluation after the competitive basketball season. X-rays were obtained and showed chondral changes within the trochlea. An MRI scan of the elbow identified small loose bodies along with chondral changes involving the posterior trochlea of the humerus. The patient underwent arthroscopic debridement of the osteochondral lesion with microfracture and removal of loose bodies. Athlete was placed in a removable elbow brace for four weeks. Rehabilitation included elbow active ROM exercises at day 1 post op and Scapulothoracic stabilization exercises. Athlete was progressed to elbow specific strengthening exercises at 6 weeks. He regained full range of motion and strength by 8 weeks following the arthroscopic procedure. At 3 months post-op, the patient returned to full court participation. Clinical evaluation at two years post-op, demonstrated maintenance of full range of motion of the elbow without pain or effusion. Final follow-up radiographs were unremarkable. **Uniqueness:** Osteochondral injuries involving the elbow are most commonly identified within the capitellum. Trochlear osteochondral defects are uncommon. The area is hypovascular due to lack of artery anastomosis. Previous case studies typically involve males but occur earlier in adolescence. Predisposing factors in the current case were minimal, with only repetitive extension as the primary factor. Additionally, ligament laxity has been speculated in previous literature but was not relevant in the current case. **Conclusions:** Terminal extension pain, a "catching" sensation and lack of resolution with conservative treatment are key indicators for a chondral injury. Previous literature indicates the possibility of increased range of motion losses when diagnosis is delayed. This was prevented in the current case with follow up evaluations and imaging resulting in a diagnosis. Arthroscopic debridement and microfracture of the trochlea may be a viable option in these rare lesions and increase the likelihood of long term success.

Chronic Elbow Injury in Intercollegiate Baseball Pitcher

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Background: A 20-year-old collegiate left handed baseball pitcher presented at beginning of academic year to Certified Athletic Trainer (ATC) stating he suffered a coronoid stress fracture during summer league participation. ATC evaluation revealed no edema, full active ROM compared bi-laterally; however, athlete presented with a 10 degree extension lag. Athlete had full strength with no reported neurological or circulatory issues noted. Valgus and Varus Stress tests were (-) with solid endpoints, (+) Valgus Extension Overload test. In consultation with Team Physician, rehabilitation program was initiated. **Differential Diagnosis:** Lateral Epicondylitis, Osteochondritis Dissecans, Valgus Extension Overload, Olecrannon Stress Fracture, Process Stress Fracture. **Treatment:** Initial treatment included six weeks of non-activity. During this time, an extensive and detailed rehabilitation focused on ROM and strengthening exercises. Exercises included wrist flexion/extension, pronation/supination, grip strength, and elbow flexion/extension exercises steadily progressing resistance each week. Shoulder exercises included scapular stabilization, proprioception, and rotator cuff exercises with weekly progression. After six weeks of pain free rehabilitation, he was cleared for the interval throwing program (ITP) and light strength training. After completing ITP, no edema or pain noted. ROM and strength were WNL and was granted full clearance. While scrimmaging one week later, he reported similar pain as initial injury to ATC were examination revealed posterolateral pain with extension. Athlete referred to Team Physician who ordered an MRI which revealed marrow edema, with a coronoid process fracture. Conservative treatment was initiated without success; thus, Team Physician proceeded with surgical intervention. Surgery identified coronoid as an intact structure and three microfractures were drilled into coronoid to initiate a healing process. Following surgery he was immobilized for 10 days, with restriction from active biceps activities for 1 month. He began rehabilitation, restoring ROM and strength. Approximately 3.5 months post-surgery, he was cleared for throwing. Athlete completed ITP and was granted full clearance. He had a successful fall and spring training, and started second game of the season, but felt pain in his elbow. ATC examination revealed swelling over posterior elbow, pain with ROM, AROM 30-100 degrees, (-) ligamentous stress tests. Athlete referred to Team Physician who ordered MRI revealing marrow edema involving coronoid process. He was withheld from participation for 6 weeks and began another rehabilitation program. After 6 weeks, athlete had full elbow ROM and strength. ATC could not elicit pain with special tests. At this time, he began ITP, reporting minimal soreness. Athlete returned for last game of season pitching successfully. However following game, athlete reported to ATC complaining of similar pain as initial evaluation. **Uniqueness:** Coronoid fractures are typically associated with posterior elbow joint dislocations with an occurrence rate of approximately 10%. Through an extensive literature search, a coronoid stress fracture is extremely rare and data supporting their occurrence is limited. This case highlights the challenges of a coronoid stress fracture in an elite throwing athlete when applying conventional stress fracture protocols. Athlete would respond well to rehabilitation until his scheduled return to competitive pitching. **Conclusions:** This case highlights extensive treatment and rehabilitation of an athlete suffering from chronic stress fractures of the coronoid process. This case is extremely unique due to the low incidence of initial and recurring coronoid process stress fractures. This case exhausted both conservative and surgical treatment options with minimal success. The case demonstrates need for ATCs to appreciate complexity of injuries associated with elite throwing athletes and understand that although conventional rehabilitation would be successful with most athletic populations, the demands of the sport ultimately played an essential role in determining final outcome of this case. Athlete was unable to continue sports participation and efforts were focused on maintaining activities of daily living.

Dynamic Ulnar Impaction Syndrome In A Collegiate Baseball Player: A Case Report

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Background: A 20-year-old NCAA Division-I male baseball player reported a gradual onset of dorsal ulnar-sided left wrist pain in the spring 2007 baseball season. Chief complaints included pain with pronation, supination, and ulnar deviation, as well as increased pain with batting, due to the excessive and forceful ulnar deviation during this motion. Strength and range of motion (ROM) were equal bilaterally. An MRI revealed soft tissue edema near the base of the third metacarpal and bone marrow edema at the triquetrum and lunate. There was no radiographic evidence of a triangular fibrocartilage complex (TFCC) tear. Following unsuccessful conservative treatment, the patient opted for exploratory wrist arthroscopy in which a large chondral defect was found and debrided from the lunate. Following rehabilitation and full return to play, the patient continued to experience persistent ulnar-sided left wrist pain with wrist flexion, ulnar deviation, and forearm pronation during batting and fielding. Fourteen weeks after the first surgery, a second exploratory wrist arthroscopy revealed that the proximal articular surface of the lunate had healed, but the new hyaline cartilage had already frayed and required debridement. A large type I-B (dorsal ulnar) TFCC tear was also found and repaired using an outside-in technique. Following a gradual activity progression and return to functional activities, the patient again complained of dorsal ulnar-sided left wrist pain, despite having full strength and full ROM. **Differential Diagnosis**: TFCC tear, lunotriquetral ligament sprain, extensor carpi ulnaris tendinopathy, chondromalacia of the lunate or ulna, Kienböck's disease, ulnar impaction syndrome, dynamic ulnar impaction syndrome. **Treatment**: Six months after the second arthroscopic surgery, another MRI revealed grade 4 chondrosis of the proximal lunate. Because all previous X-rays had shown normal ulnar variance with the forearm in a neutral rotation, a pronated grip X-ray was also taken, revealing a positive ulnar variance in that position. To avoid compromising the integrity of the distal radioulnar joint (DRUJ) and the TFCC with another arthroscopic surgery, an extra-articular procedure called an ulnar shortening osteotomy was performed to decompress the ulnocarpal joint and tighten the extrinsic ulnocarpal ligaments to provide additional stability to the DRUJ. After this third surgery, the patient was able to return to full participation in baseball practice and training until a knee injury prevented his return to competition. **Uniqueness**: Using traditional X-ray with the wrist and forearm in a neutral position, the patient showed no indication of positive ulnar variance, which is usually an underlying cause of ulnar impaction. Although positive ulnar variance is often congenital, this case presents strong evidence that it can also occur during functional or dynamic tasks, as the space between the distal ulna and the carpal bones diminishes with pronation and gripping. X-rays taken in this prone, gripping position were important in confirming the diagnosis of "dynamic" ulnar impaction syndrome because the baseball player's grip of the bat is mimicked, and when ulnar deviation is added during the baseball swing, the already decreased space between the ulna and carpal bones becomes even smaller as the structures in this space are impinged. **Conclusions**: Because of the variety of pathologies that can occur at the wrist, differential diagnosis of patients with idiopathic wrist pain can often be difficult. Even in individuals who do not present with a positive ulnar variance on traditional radiography, a diagnosis of ulnar impaction syndrome should be considered in patients with ulnar-sided wrist pain, especially in athletes who participate in club or racquet sports. Recognition and understanding of ulnar impaction syndrome and dynamic ulnar impaction syndrome may lead to more effective treatment and diagnosis of patients who suffer from ulnar-sided wrist pain.

Free Communications, Oral Presentations: Non-Mechanical Factors Associated with Injury

Thursday, June 27, 2013, 3:15pm-4:30pm; Palm D: Moderator: Reed Ferber, PhD, ATC

Epidemiology Of Basketball, Soccer And Volleyball Injuries At The Middle School Level

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Context: There are an estimated 30 million school aged kids participating in sports in the United States. This represents a greater than 20% increase over the past decade. Of these 30 million participants, 34% of middle school aged participants become injured and seek medical treatment at an annual cost of close to $2 billion. Middle School athletics show increasing need for services provided by a certified athletic trainer (ATC). Objective: To describe the epidemiology of injuries documented in the middle school setting over the course of three sport seasons. Design: Cohort Study. Setting: Middle School and Controlled Laboratory. Patients or Other Participants: Female basketball, soccer and volleyball players were recruited from a single county public school district in Kentucky consisting of five middle schools. A total of 268 subjects (162 basketball, 26 soccer and 80 volleyball) participated as entire teams, resulting greater than 95% recruitment and data monitoring. Interventions: Athletes were monitored for sports related injury by an ATC during each sports season. Injury was operationally defined as causing cessation of participation in the current game or practice and prevented return to that session or the day following and any fracture, even if the athlete did not miss a session. Athlete exposures were recorded on a weekly basis. Exposure data was submitted by the coach into the SISS (Sports Injury Surveillance System). Injuries were recorded in SIMS (Sports Injury Monitoring System). Main Outcome Measures: Athlete risk of injury was calculated for each sport and across all sports. Injury rate was calculated for specific types of injuries within each sport. Results: A total of 134 injuries were recorded by the ATC over the three sport seasons. Basketball had the most reported injuries at 84 (52% risk), followed by Volleyball with 38 (47.5%) and then soccer with 12 (46.1%). The overall rate of injury for basketball was 4.20 per 1000 AE for games and 2.24 per 1000 AE in practice. Soccer game rate was 9.05 per 1000 AE and 5.27 per 1000 AE in practice. The injury rate in volleyball was higher for practice (5.55 per 1000 AE) than for games (0.75 per 1000 AE). The relative risk of injury was more than twice as high in soccer compared to basketball. Injuries to the knee were the most common (99 injuries out of 134 or 73.9%) of which PFD (31.3%), OSD (10.4%) and SLJ/patella tendonosis (9%) had the greatest incidence. Ankle was the second most commonly injured body part accounting for 16.4% of all injuries. Conclusions: Middle school aged athletes displayed comparable injury patterns to those seen in their high school counterparts. Future work is warranted to determine the potential for improved outcomes in middle school populations with access to ATC services.

Patients With Osteoarthritis And A History Of Sport Participation Consume More Medication And Supplement For Managing Joint Symptoms Than Patients With Osteoarthritis And No History Of Sport Participation: A Cross-sectional Study

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Context: Osteoarthritis is prevalent among athletes with a history of joint trauma or participation in high-risk sports. To provide better care for this patient population we need to understand how patients with and without a history of sport participation (HxSP) manage joint symptoms. Objective: The purpose of these analyses was to determine if patients with and without a HxSP consume medications/supplements differently to manage joint symptoms. Design: Secondary analysis of a cross-sectional study (Driban et al., BMC Musculoskelet Disord. 2012). Setting: Urban hospital-based outpatient orthopedic practice. Patients: We recruited a convenience sample of 184 patients with a primary complaint of hip or knee osteoarthritis (22 patients were excluded or declined to participate). Hence, 162 patients were included. The sample included 70 (43%) patients without a HxSP: 79% female, 77% African descent, 58±10 years old, body mass index=34.7±7.2 kg/m^2, 36% less than a high school or equivalent education, and 51% reported a diagnosis of arthritis at

multiple joints. Additionally, 92 (57%) patients had a HxSP: 58% female, 70% African descent, 61±11 years old, body mass index=35.7±8.2 kg/m^2, 21% less than a high school or equivalent education, and 63% reported a diagnosis of arthritis at multiple joints. Most HxSP patients competed at the recreational (35%) or high school (47%) level. Interventions: One trained investigator administered four interview-based questionnaires to obtain information about the participant's health history, sport participation, and pharmacological/supplemental use. The questionnaires were developed by the research team and reviewed by two statisticians. Main Outcome Measures: The questionnaires were an item-by-item design where each question could be scored individually. We used Fisher Exact Tests and logistic regression models to determine if a HxSP was associated with patterns of medication/supplement use. Odds ratios (OR) and 95% confidence intervals (CI) were calculated. Results: Patients with a HxSP (49%) more often consumed $\geq$2 medications/supplements for their joint symptoms than patients without a HxSP (29%; OR=2.4, 95%CI=1.3 to 4.6). This was true even after adjusting for gender, education, ethnicity, or reported diagnosis of arthritis at multiple joints. Both groups occasionally or never consumed their medication consistently (with HxSP=44%, without HxSP =44%; p=1.00). Finally, patients with and without a HxSP (15%, 18%; respectively) had a similar frequency of patients reporting their medication as ineffective or required a stronger medication to manage joint symptoms. Conclusions: Similar to findings that current and retired football players may misuse analgesic medications we found that patients with a HxSP may consume more medications to manage their joint symptoms than patients without a HxSP. To promote safer and more efficacious treatments for patients with a HxSP we need to find new strategies to better educate and communicate with HxSP patients about safe medication use.

Sleep Quantity, Sleep Quality and Daytime Sleepiness Assessment in Collegiate Athletes

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Context: Sleep is an important component of health and can affect normal psychological and physiological function. Poor sleep has been associated with suboptimal athletic performance therefore it is important for athletic trainers to assess sleep in patients. There are 3 main characteristics associated with sleep assessment: quality, quantity, and daytime sleepiness. Currently, there is scant research in athletic training examining the relationship between these characteristics in collegiate athletes. Objective: To examine the relationship between the 3 characteristics of sleep in female collegiate athletes. Design: Cross-sectional. Setting: Clinical athletic training setting at a NCAA Division I institution. Participants: A total of 43 female student athletes (Age: mean ± SD: 19.57 yrs ± 0.86) volunteered for this study. Power analysis for a correlation of 0.3 with a power 0 of 0.80 indicated a sample size of 42. Intervention: Participants wore an accelerometer to assess sleep quantity on their wrists while sleeping for 7 consecutive nights. At the end of the data collection period, participants completed computer adaptive PROMIS sleep-related impairment (SRI: daytime sleepiness) and sleep disturbance (SD: sleep quality) instruments. Validity of these sleep measures has been well established in other disease populations. Main Outcome Measures: The dependent variables were T scores from the SRI, SD, and the 6 accelerometry variables. Using the ActiLife5 software, the Sadeh algorithm was used because of the age of the population. The algorithm produced the 7-day average

of the six key accelerometry sleep variables: latency (L), total sleep time (TS), time awake (TA), number of awakenings (A), average awakenings (AA), and sleep efficiency (SE). Relationships between the 3 characteristics were examined using Spearman Rho correlations. The PROMIS scores were expected to have negative correlations with SE and TS and to have positive correlations with A, AA, TA, and L. Alpha was set at 0.05. Results: There were significant correlations between SRI and SD (r = .42; P<0.05) and SD and TS (r = -0.31; P<0.05). There were no other significant correlations. The sleep quantity scores (mean ± SD) were: L = 9.56 ± 9.24 min, TS = 391.67 ± 56.02 min, TA = 95.34 ± 10.26 min, A = 19.48 ± 5.16 times, AA = 3.65 ± 1.31 min per time, and SE = 85 ± 5.69 percent. SRI mean score (T score) was 56.1 ± 5.76 and SD was 51.88 ± 7.19. Conclusion: Our results indicate that the three important characteristics of sleep in a collegiate population are independent of each other and need to be assessed individually. Athletic trainers should be aware that sleep quality, sleep quantity, and daytime sleepiness should be assessed and PROMIS adaptive instruments and accelerometry together provide a clinically useful and easy way of measuring sleep.

Relationship Between Rehabilitation Related Mental Toughness, Mood, And Anxiety After Injury

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Context: Many elite athletes experience mood disturbances (e.g., depression) and stress after being injured during practice or competition. These negative psychological reactions to injury can reduce adherence to rehabilitation protocols impacting recovery outcomes. Mental toughness has been shown to be associated with better adherence to rehabilitation protocols, however the relationship between mental toughness and psychological variables after an injury has occurred has yet to be examined. **Objective:** To determine the relationships among mental toughness, mood state, and anxiety in injured collegiate athletes. **Design:** Cross-sectional. **Setting:** NCAA Division I athletes at a public university. **Patients or Other Participants:** Thirty-four (n = 15 females) collegiate athletes (20.0 ± 1.6 years of age) from 8 varsity sports injured during practice or competition. **Interventions:** Injured athletes provided informed consent and then completed the study surveys on a laptop in the athletic training room. The surveys completed assessed mental toughness (Mental, Emotional, and Bodily Toughness Inventory for Rehabilitation [MeBRecover]), mood disturbance (Profile of Mood States), and perceived stress (Perceived Stress Scale). **Main Outcome Measures:** Pearson product-moment correlation coefficients (r) were calculated among the total scores from the surveys to determine if mental toughness was associated with post-injury mood disturbance and perceived stress. **Results:** Mean ± SD for the surveys are as follows: Profile of Mood States total mood disturbance (27.27 ± 1 3.52), Perceived Stress Scale (17.59 ± 7.13), and MeBRecover (130.78 ± 13.08). Mental toughness levels were significantly correlated with total mood disturbance (r = -.47, p = .007) and perceived stress (r = -.52, p = .002), indicating that higher levels of mental toughness were associated with less mood disturbance and stress after injury. **Conclusions:** This research provides evidence of relationship between mood disturbances, stress, and mental toughness after injury. Mental toughness is a potentially modifiable variable. The results of this research suggest that an intervention aimed at modifying mental toughness may have a positive impact on psychological responses to injury and potentially improve rehabilitation adherence and outcomes.

Return-To-Play Probability Estimates Are Affected By Which Knee Ligament Is Injured

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Context: Knee sprains are the second most common sports-related injury; tissue damage alone is not a precise indicator of when an athlete will return-to-play (RTP). Objective, evidence-based estimates of RTP following a knee sprain are needed. **Objective:** To determine RTP probability timelines amongst the 4 major ligaments of the knee following a sprain. **Design:** Observational, epidemiological. **Setting:** Secondary data analysis of High School RIO™ database. **Patients or Other Participants:** High school athletes with knee sprains sustained during school-sanctioned athletic participation (mean±SD: age=16.0 ±1.2yrs, height =177.3±10.2cm; mass= 77.5 ±18.7kg). **Interventions:** New knee sprains were classified by which ligament was documented as injured: anterior cruciate (ACL), posterior cruciate (PCL), medial collateral (MCL), lateral collateral (LCL). Only single-ligament injuries were considered for analysis. A *new injury* was defined as an acute knee sprain with no prior history of that same injury. **Main Outcome Measures:** Kaplan-Meier(KM) estimators [censored data] were stratified by ligament damaged and used to statistically compare the probability of time until RTP (T-RTP) after new knee sprain for each ligament. Cases for which the athlete did not RTP (medical disqualification or season ended before the athlete was released) were considered censored. For the estimators, each knee sprain was analyzed based on RTP status (return, no return) at specified timeframe intervals (1-2 day return, 3-6 days, 7-9 days, 10-21 days, > 22-days, no return [censored]). Alpha levels were set at $p<.05$. **Results:** A total of 1,332 new, single-ligament knee sprains were considered for analysis (ACL=340 [227 censored], PCL=35 [12 censored], MCL=799 [168 censored], LCL=158 [31 censored]). There was a significant difference in median T-RTP amongst each ligament ($P<.0001$). The median T-RTP for ACL=22 days (IQR=22,22); PCL=10 days (IQR=3,22); MCL=10 days (IQR=3,22); LCL=7 days (IQR= 3,22). Selected results are presented to highlight characteristics of the KM curves generated. The T-RTP probability [exact 95% confidence intervals] of return by 7-9 days for an injury to the ACL=8.3% [5.8,11.8]; PCL=31.7% [18.9,49.9]; MCL= 39.3% [36.0,42.8]; LCL=51.9% [44.4,59.9]. The probability of return by 10-21 days for an injury to the ACL=15.5% [12.1,19.1]; PCL= 52.5% [37.0,69.7]; MCL =65.4% [62.1,68.7]; LCL=72.0% [64.9,78.9]. The lowest probability of return at every timepoint was due to ACL injury. Curves for the MCL and LCL indicated the highest probabilities of return at all time points. **Conclusions:** RTP after a single ligament injury is affected by which ligament was damaged. As expected, ACL injuries had the highest proportion of censored cases, and the least likelihood to RTP at all time points following injury. The likelihood of RTP following MCL or LCL injuries was far higher than that of the cruciate ligaments. RTP probabilities can assist clinicians with providing accurate prognoses for athletes, in particular when surgery is not likely to be indicated. Further time-to-event analysis of combination-ligament injuries is warranted.

The Effects Of Ankle Kinesio Taping On Muscle Activity During A Drop Landing Maneuver

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Context: Kinesio tape (KT) has recently gained popularity in the prevention and treatment of athletic injuries, specifically in the lower extremity. Previous research has supported increases in ankle stiffness with use of KT; however, it is unclear whether this is a result of increased muscle activation or the mechanical properties of the tape. **Objective:** To examine the immediate and prolonged effects of KT application at the ankle on lower-leg muscle activity during a drop landing. **Design:** Single group pre-test, post-test. **Setting:** Climate-controlled biomechanics laboratory. **Patients or Other Participants:** Twenty-two subjects (20.0±1.4yrs; 72.0±9.8kg; 170.0±14.9cm) with no history of ankle pathology volunteered for this study. **Interventions:** Subjects were asked to jump from a 35cm box on to an in-ground forceplate and immediately jump to a height equal to 50 percent of their maximum vertical jump. Surface electromyography (EMG) was collected from the tibialis anterior (TA), peroneus longus (PL) and lateral gastrocnemius (LG) muscles and synchronized at 1000Hz with forceplate data. Five trials were collected under each of 3 conditions: prior to ankle KT application (BL), immediately after tape application of (KT-I), and following 24-hours of use (KT-24). Kinesio tape application followed techniques reported in previous research, using an anterior strip applied distal to proximal, a stirrup applied from medial to lateral, and transverse strip applied over the anterior ankle. **Main Outcome Measures:** Peak force (N) from landing was compared with a repeated-measures ANOVA with one within-subject factor (Condition). Average EMG (% ensemble peak) was calculated 250ms prior to landing (PRE), 0-250ms (POST-1) and 250-500ms (POST-2) after forceplate contact. EMG measures were compared with a 3-way ANOVA wih three within-subject factors (Condition, Muscle, Time). **Results:** No significant differences were observed for peak force ($F_{2,40}$=1.349, BL=1809.5±824.6N, KT-I=1758.0±784.5N , KT-24= 1911.6±1060.0N , p=0.27). A significant interaction effect for average EMG was observed between condition, muscle, and time ($F_{8,160}$=4.19, $p<0.001$). Pairwise comparisons revealed TA activity at POST-1 decreased from BL (62.2±14.1%) to KT-I (48.1±24.5%, p=0.027), and trended toward a decrease at KT-24 (47.7±26.2%, p=0.054). Furthermore, PL activity at POST-2 decreased from BL (46.9±23.5%) to KT-24 (27.3±23.5%, p=0.022). **Conclusions:** Our data demonstrate a decrease in TA and PL muscle activity with KT application. While this effect appears undesirable, as no changes in peak force were observed, these results could suggest that individuals were able to maintain performance level with less muscle activity. While previous research has reported both muscle facilitation and inhibition following KT use, few have studied these variables with a measure of performance or joint mechanics. To investigate whether this muscle inhibition is beneficial or detrimental, future studies might test the effect of KT on muscle activation and performance during a more complex landing task.

Comparison Of Gluteus Medius Activation Between Weight Bearing And Non-Weight Bearing Limbs During A Functional Assessment Of Hip Abduction Strength

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Context: Decreased function of the gluteus medius (G_{med}) leading to dynamic lower extremity malalignments has been suggested to increase the risk of knee injuries. However, the relationship between G_{med} function and dynamic lower extremity motion remains unclear. This may be attributed to the measurement methods of hip abduction function that are commonly performed in side lying, non-weight bearing positions, which may not accurately reflect G_{med} function during weight bearing, functional activities. Assessing G_{med} function in a functional position may require greater activation to stabilize the pelvis in a single limb stance. **Objective**: To examine the differences in G_{med} activation between the weight bearing (WB) and non-weight bearing (NWB) limb during a functional assessment of hip abduction strength. **Design**: Descriptive laboratory study. **Setting**: Research laboratory. **Patients or Other Participants:** Twenty (10 males, 10 females) healthy collegiate aged participants (24.9±3.9 yrs, 171.7±7.9 cm, 71.6±14.9 kg) volunteered for this study. **Interventions**: Gluteus medius surface electromyography signals (sEMG) of the WB and NWB limb were measured as participants performed 3 standing hip abduction maximum voluntary isometric contractions (MVIC) of the right and left limbs (hip abducted 5°) on an isokinetic dynamometer. Excellent

day-to-day reliability of torque production was previously demonstrated for this standing measure ($ICC_{2,k}$=0.91, SEM=0.03 $Nm \cdot kg^{-1}$). **Main Outcome Measures**: The maximum root mean squared amplitudes (volts) of the WB and NWB G_{med} across 3 trials were used for analysis. Paired samples t-tests determined the difference between G_{med} activation of the WB and NWB limbs. **Results**: The maximum root mean square amplitudes during right hip abduction MVIC for the WB and NWB G_{med} were 0.369±0.205 and 0.275±0.155 volts, respectively. The maximum root mean square amplitudes during left hip abduction MVIC for the WB and NWB G_{med} were 0.375±0.216 and 0.262±0.183 volts, respectively. The maximum root mean square amplitudes of the WB G_{med} was significantly higher than the NWB G_{med} during both right (paired difference = 0.090 volts, P<0.001) and left (paired difference = 0.097 volts, P<0.001) hip abduction MVIC. **Conclusions:** Activation of the G_{med} was greater on the WB compared to the NWB limb when assessing hip abduction MVIC in a functional, WB position. In order for the NWB limb to produce an abduction force, greater activation of the WB G_{med} may be necessary to meet the increased demand to stabilize the pelvis and trunk. Assessing hip abduction MVIC in a more functional position may be a more accurate representation of G_{med} function when examining the role of the hip abductors in controlling lower extremity motion during dynamic activities and their contribution to the increased risk of knee injuries.

Metabolic Disorder In A Collegiate Football Player

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Background: A 17 year-old African-American male (179.8cm, 79.4kg) presented to the athletic trainer with thirst, fatigue, shortness of breath, dizziness, muscle pain, cramping, and weakness shortly after completing sprints during an August intercollegiate football practice. On-site evaluation by the athletic trainer identified confusion, tachycardia, respiratory distress, significant loss of extremity motion, and inability to self-ambulate. The patient's medical history was significant for a cramping and vomiting episode associated with summer football camp at age 15, and sickle cell trait. **Differential Diagnosis:** Exertional heat stroke, rhabdomyolysis, sickle cell crisis, McArdle disease, Tarui disease, and malignant hyperthermia. **Treatment:** After initial evaluation, an immediate attempt to orally rehydrate and rapidly cool the patient was performed by the athletic training staff. EMS was activated and administered on-site IV fluids and transported the patient to the emergency department. Upon arrival at the hospital, blood tests were ordered, revealing changes in electrolyte levels and blood chemistry. Creatine kinase (CK) levels were significantly elevated (2540 U/L). At the hospital, the patient was stabilized, prescribed Dantrium® for two weeks, instructed to follow up with his health care provider, and released. After following up with the athletic trainer, the patient was referred to the team physician who ordered additional blood tests and restricted the patient from athletic participation while awaiting results. Status-post two days, CK levels remained elevated (1710 U/L) and the patient was subsequently referred to a neurologist, nephrologist, and cardiologist. All examinations and additional diagnostic testing was inconclusive. The team physician further disqualified the patient and instructed the athletic training staff to monitor his condition. Status-post 11 weeks, blood tests revealed that the patient's CK levels remained elevated (914U/L). The patient was diagnosed with non-anesthesia malignant hyperthermia because he continued to demonstrate hyper-CK-emia for which the etiology remained unclear. The absence of a muscle biopsy and subsequent caffeine halothane contracture test, which is only offered at five centers in the US, created an inability to identify the etiology of the case and prevented a definitive diagnosis. The patient was cleared for unrestricted activity by the team physician and was instructed to report any changes in health status to the athletic training staff. **Uniqueness:** Malignant hyperthermia is rare, although its prevalence has not been established due to a lack of universal reporting. This case is unique because the presence of the hematological and metabolic conditions that manifested, in conjunction with the inability to obtain the necessary diagnostic testing, made the definitive diagnosis, management, and return to activity clearance complex. Also, blood CK levels normally range from 22 to 198 U/L, depending on gender, activity level, and ethnicity. This patient's CK levels were 23 times normal and he continued to demonstrate hyper-CK-emia status-post 11 weeks, for which the etiology remained unclear. A lack of research exists about the safety of athletic participation and clinical interventions associated with malignant hyperthermia. **Conclusion:** Malignant hyperthermia is a rare, life-threatening, inherited hyper-metabolism syndrome characterized by muscle abnormality triggered by anesthesia, muscle relaxants, intense exercise, and/or hyperthermia. In non-anesthetic malignant hyperthermia cases such as this, an abnormal ryanodine receptor in skeletal muscle affects function when until exposed to

intense exercise or hyperthermia. A biochemical chain reaction begins that causes abnormal release of calcium from the sarcoplasmic reticulum. This then results in excessive calcium in skeletal muscles, leading to sustained muscle contractions and an increase in muscular metabolism. ATP depletion is then followed by rhabdomyolyses, which causes the release of potassium and myoglobin into the blood stream. Ultimately cardiac abnormalities and renal dysfunction result. Such cardiac and renal complications include metabolic and respiratory acidosis, heat production, sympathetic nervous system activation, hyperkalemia, and blood coagulation irregularity.

Determination Of Microbial Populations In A Synthetic Turf System

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Context: There is growing concern regarding the contribution of infilled turf fields on athlete infections. Abrasions that occur on these fields create a portal of entry for pathogens such as *Staphylococcus aureus*. **Objective:** This study compared the occurrence of microbial populations on two infilled turf fields (year old turf in stadium vs. 6 year old turf in practice field) in three locations on each field. It was hypothesized that the older turf field will contain higher microbial populations, therefore, presenting greater risk. **Design:** Infill material from both fields was sampled weekly at each site for 5 months through the football season with microbial enumeration done on three selective media. **Setting:** Sites sampled include the sideline, the middle of the field, and the end of the field on both fields. **Interventions:** Tryptic Soy Agar will be used to determine total microbial load, Mannitol Salt Agar for *S. aureus*, and Eosin Methylene Blue Agar to determine the number of coliforms such as *Escherichia coli*. Main Outcome Measures: A comparison was done between the two fields at each site to determine differences between microbial loads. Means at each site were determined and compared both for each sample time and over the test period. **Results:** Higher microbial populations were found on the older turf field (as much as a 1E+04 increase over similar locations on the newer turf), as well as in areas of high traffic such as the sidelines. This suggests microbial populations can accumulate in synthetic turf infill from year to year. When comparing the bacterial load on different areas of the field, the sideline has the highest counts with an average of 1.60E+08 CFUs per gram of rubber infill on the older turf. On the new turf, the area with the highest number of total microorganisms was the end of the field rather than the sideline, with an average of 3.09E+05 CFUs per gram of infill. This is probably due to practices held on the stadium turf field rather than actual game play. A high number of salt-tolerant, mannitol fermenting bacteria (indicators of *S. aureus*) were also found, an average of 3.25E+02 CFUs per gram on the new turf and 2.73E+03 CFUs per gram on the older turf. *Escherichia coli* was isolated using EMB agar on the newer turf, in an area of high usage. **Conclusions:** These results indicate that infill material can serve as a source for the spread of pathogens among athletes and that these organisms seem to accumulate over time posing a greater risk if proper cleaning is not routinely performed.

Velocity And Acceleration Of The Head During Emergency Shoulder Pad Removal

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Context: As American football equipment designs introduce new technology to improve safety, evidence-based techniques for their emergent removal must coincide. Previous research in emergency removal of shoulder pads has investigated the time for removal and the induced motion within the cervical spine. Velocities and accelerations of the head and cervical spine during these interventions are important considerations that have not been extensively studied. **Objective**: To examine head velocity and acceleration when removing two styles of football shoulder pads. We hypothesized that a new quick release style of shoulder pads would result in less acceleration and velocity at the head during shoulder pad removal. **Design**: Quasi-experimental. **Setting**: Research laboratory. **Patients or Other Participants**: Forty certified athletic trainers (ATs) free of physical pathology preventing them from completing the required tasks were recruited (males=21; females=19; age=33.7±11.2 yrs; mass=80.7±17.1 kg; height=173.1±9.2 cm; AT experience=10.6±10.4 yrs). **Interventions**: The independent variable was the shoulder pad design (Traditional or Riddell RipKord™). After practicing and familiarizing themselves, paired participants conducted 8 successful, randomized trials where they removed traditional (Trad) shoulder pads (using the flat torso technique) or RipKord™ (Rip) shoulder pads from a live model (4 trials of each). An eight-camera three-dimensional motion system with two, three-point segment marker sets (head and torso) were used in capturing head and torso motion. Kintrak 6.0 and Eva-RT 5.0 (Motion Analysis, Inc.) software was used to digitize motion trials and process the outcome variables. **Main Outcome Measures**: Dependent variables involved integrated velocity and integrated acceleration of the head in each of the three planes (sagittal, frontal, transverse). Trials for each pair were ensemble averaged. Due to our participant pairing, our analyses were based on a sample of n=20. Six paired samples t-tests compared means in each plane (Pd"0.05). **Results**: Removing traditional shoulder pads resulted in significantly less acceleration compared to removing RipKord™ shoulder pads in the sagittal [(t_{19} = -4.404,P<.001) Trad =1964.53 ±639.01 m/s^2, Rip= 2915.47±780.02 m/s^2], and frontal [(t_{19}= -2.620, P=.017) Trad= 842.32±336.22 m/s^2, Rip=1255.55 ±566.91 m/s^2] planes. Removing traditional shoulder pads also resulted in significantly less velocity in all three planes [[(t_{19}= -4.194, P<.00) Trad=94.63±23.44m/s, Rip= 136.07 ±38.49 m/s; (t_{19}= -3.822, P=.001) Trad=35.60 ±8.22 m/s, Rip= 49.30±15.01 m/s; (t_{19}= -2.632, P=.016) Trad= 55.83±16.74 m/s, Rip=70.60±20.55 m/s]. **Conclusions**: Our hypotheses were rejected in that the data presented suggest that when using the flat torso technique, a traditional style of shoulder pads will result in lower velocity and acceleration of the head compared to the RipKord ™ shoulder pads. This data does not reflect the amount of motion experienced in the cervical spine at time of removal. Future research should investigate these variables in different styles of shoulder pads using other removal techniques (i.e., full body levitation, torso lift). This study was funded by the Eastern Athletic Trainers' Association and the Hamel Center for Undergraduate Research.

Career And Family Aspirations Of Female Athletic Trainers Employed In The NCAA Division I Setting

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Context: Evidence suggests that female athletic trainers (FAT) depart the profession of athletic training after the age of 28. Factors influencing departure are theoretical, but include burnout, job dissatisfaction, and motherhood. Professional demands, particularly at the collegiate setting, have also been at the forefront of anecdotal discussion on departure factors. **Objective:** Gain a better understanding of the career and family intentions of FATs employed in the collegiate setting. **Design:** Structured, online asynchronous interviews via QuestionPro™ **Setting:** NCAA Division I Collegiate Setting. **Patients or Other Participants**: 26 FATs (single=14; married=6; married with children=6) employed in the NCAA Division I setting volunteered. Average age of the participants was 34 ± 8. All were full-time BOC certified with an average 11 ± 7 years of clinical experience. All FATs were on 12 month contracts, were responsible for medical coverage for an average of 2 ± 1 teams, and worked on average 59 ± 18hours a week. **Data Collection and Analysis:** All FATs responded to a series of open-ended questions via reflective journaling. Data was stored on QuestionPro™ a secure data tracking website and the study was piloted prior to data collection. Data was analyzed borrowing from the principles of general inductive approach. Trustworthiness was established by peer review, member interpretive review, and multiple analyst triangulation. **Results:** Our participants indicated a strong desire to *focus on family* or to *start a family* as part of their personal aspirations. Professionally, many FATs were unsure of their longevity within the collegiate setting or even the profession itself, the major stimuli included job demands and time. Only 3 FATs indicated a professional goal that included *persisting* at the Division I setting regardless of their family or marital status. Six FATs plan to *depart* the profession entirely due to conflicts with motherhood and the role of the athletic trainer. The remaining 17 FATs indicated a plan to make a *setting change* to balance the roles of mother and athletic trainer because the Division I setting was not conducive to parenting. All participants indicated that no formal policies were in place to help FATs balance their roles as both a mother and collegiate athletic trainer. **Conclusions:** Our results substantiate previous research, which indicates the Division I setting can be problematic for FATs and stimulates departure from the setting and even the profession. Only a small few indicated an intention to remain in the collegiate setting long-term due to constraints related to the role of the athletic trainer in the collegiate setting and its impact on being a good mother. Those who intended to persist were reliant on personal and work support networks, common work life balance strategies. Future research may investigate the role of mentorship on the retention of FATs who are also mothers.

Patient-Centered And Clinical Outcomes Associated With Grade II Lateral Ankle Sprains: A Case Series

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Background: The purpose of this case series is to describe the clinical and patient-centered outcomes of 5 collegiate athletes who presented to their respective athletic training facilities with grade II lateral ankle sprains. These patients (2 female, 3 male; age=19.4±0.8years) were participating in NCAA athletics (lacrosse, track, soccer and baseball) and sustained a lateral ankle sprain associated with an inversion mechanism while running or landing. Four patients reported no previous history of ankle sprain. All patients exhibited mild-to-moderate instability with manual stress tests (anterior drawer and talar tilt), point tenderness over the lateral ankle ligaments, limited ROM compared to the contralateral ankle, pain with weight-bearing, and sudden onset of edema within 72 hours of injury. All patients were monitored over the course of treatment using objective clinical measures (OCM) including pain, the global rating of change scale (GROC), and active dorsiflexion range of motion (DROM) along with self-reported measures of health including the Foot and Ankle Ability Measure (FAAM), the FAAM-Sport, the Cumberland Ankle Instability Tool (CAIT), and the Tampa Scale of Kinesiophobia-11 (TSK-11). While the FAAM, FAAM-Sport, and CAIT are patient reported outcomes (PRO) focusing on regional measures of health associated with the foot and ankle, the TSK-11 describes the fear of movement. Treatment: Treatment and rehabilitation protocols for each patient were dependent upon the discretion of their respective athletic trainer. Patients completed PRO and

OCM one day post-injury (Day1), one week post-injury (Week1), and at return to play (RTP)(19.6±5.86days). Active DROM was measured in degrees with the patient in prone position with the knee extended. Pain was measured in centimeters using a visual analog scale (VAS) and changes in self-reported injury status were measured using the GROC. The FAAM contains 21 items related to activities of daily living (highest score=100%), the FAAM-Sport contains 8 items related to sport-specific activity (highest score=100%), and the CAIT contains nine items pertaining to instability during activity (highest score=30). All items on the FAAM, FAAM-Sport, and CAIT are graded on a Likert scale with higher scores indicating greater self-reported function. The TSK-11 is an 11-item questionnaire graded on a 4-point Likert scale (total=44, lowest=11) with higher scores indicating greater fear of movement. **Results:** All patients demonstrated improvements in OCM as indicated by changes in DROM (Day1=6.6±8.47°; Week1= 10.6±5.32°), pain on the VAS (Day1=5.28±2.41cm; Week1 =1.5± 1.19cm) and the GROC (Day1= -0.02±2.0; Week1=2.8±0.83). The improvements in OCM corresponded to improvements in overall health status as indicated by changes in PRO measures for the FAAM (Day1= 55.50±20.00%; Week1 =79.00 ±23.50%), the FAAM-Sport (Day1= 11.87±3.56%; Week1 =27.50 ±6.38%), the CAIT (Day1= 8.20±7.43; Week1= 13.60± 7.43) and the TSK-11 (Day1=26.80±3.27; Week1=22.20±3.03). The GROC continued to improve at RTP (4.5±0.55) while pain (0.06±0.09cm) and DROM (10.6±7.13°) did not change. Upon RTP, all patients demonstrated high levels of function on each PRO measure (FAAM =98.50±2.05%; FAAM-Sport= 96.25 ±5.59%; CAIT=24.60±3.21; TSK-11=16.00±2.34) indicating minimal functional loss. Uniqueness: There is a lack of evidence supporting the use of PRO and OCM to track the progress during rehabilitation of lateral ankle sprains. This case series demonstrates how patient-centered measures of function can be used to enhance patient evaluation and track rehabilitation progress when combined with traditional clinical indicators of function. **Conclusions:** Following lateral ankle sprain, patients demonstrated decreases in pain, increases in DROM, and improvements in perceived injury status which corresponded with improvements in self-reported measures of health assessed through PRO instruments. All patients demonstrated improvements in OCM and PRO at RTP regardless of their rehabilitation plan. However, PRO instruments continued to identify improvements at RTP despite a plateau in certain OCM. This demonstrates the benefit of combining OCM and PRO for tracking the rehabilitation progress for patients with lateral ankle sprains.

Multiple Joint Inflammation Within A Division IA Football Defensive Tackle

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Background: The individual is a 21 year old African American division IA football athlete. The athlete is a 330 pound defensive lineman with a history of arthritis within his right shoulder and both knees. After playing in a game the athlete presented with a fever of 100.9 degrees. He reported some minor joint pain in his right wrist and right great toe but the fever was his main complaint. The athlete's wrist and great toe were found to have full range of motion and no pain limiting motion. The athlete was treated for his fever with fluids, ibuprofen, and cold relief medication. The following day the fever subsided but the pain in the athlete's great toe and wrist increased. The joints were re-evaluated and immobilized due to limited motion and pain. Athlete was referred to a team physician for further evaluation. **Differential Diagnosis:** Turf Toe, Tenosynovitis of the wrist, Inflammatory arthritis **Treatment:** The team physician ordered X-rays for both joints which were negative for fracture in both joints. After one day of being immobilized in a walking boot, a large amount of swelling and pain developed in his left knee. The athlete admitted himself to the emergency room due to his increased swelling and pain. The following day after being released from ER, the athlete had a MRI of his wrist and knee x-ray as ordered by the team physician. MRI results of the wrist showed tenosynovitis of the extensor digitorum tendon and the knee x-ray was negative for fracture. The team physician aspirated 120cc of murky yellowish fluid removed from his knee. After seeing the appearance of the aspirated fluid, the team orthopedists ordered laboratory tests

to be conducted on the fluid. The results showed that the cell count with differential demonstrated elevated WBC count. Due to the elevated WBC, the team physician was worried about the possibility of infection in the athlete's knee. The team physician ordered the athlete to be admitted to the hospital for further evaluation and he was given I.V. antibiotics for two days. Infectious disease doctors from the hospital ER diagnosed the athlete with having either inflammatory arthritis or disseminated gonococcal arthritis pending the athlete's lab results. The athlete was discharged from the hospital by the team physician with a prescription of Suprax to take twice a day for two weeks. Suprax is an antibiotic prescribed to treat bacterial infections.The athlete was monitored closely by the athletic training staff over the next two weeks to ensure the athlete was compliant with taking his medication. Over the course of the two weeks the athlete's symptoms subsided. The athlete was gradually returned to play and able to finish the remainder of the football season without a reoccurrence. **Uniqueness:** This case was unique due to the rapid onset of symptoms the athlete experienced within a short time period. The staff believed that all of the injuries were correlated to the inflammatory arthritis that attacked several joints in the athlete's body. The athlete had typical presentation of inflammatory arthritis although this condition is normally seen within an older age group of adults. The incidence rate of this kind of inflammatory arthritis is very rare in athletic populations. **Conclusions:** This case is important because athletic trainers must be mindful of septic and inflammatory arthritis in athletes with sudden onset of swelling and pain within multiple joints. Given the results of the laboratory tests, the medical staff diagnosed this athlete with inflammatory arthritis which was treated with appropriate medicine and allowed return to full participation in sixteen days.

The Landing Error Scoring System: Do Jump-Landing Patterns Differ Based On Sport?

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Context: The Landing Error Scoring System (LESS) is a clinical screening tool used to assess jump-landing patterns and identify individuals who may be at-risk for an anterior cruciate ligament (ACL) injury. While previous investigations have identified sex and age differences in jump-landing patterns, it is unclear whether other group differences exist. **Objective:** To determine whether jump-landing patterns, as assessed by the LESS, differ based on sport. **Design:** Cross-sectional. **Setting:** Athletic training facilities. **Patients or Other Participants:** Two-hundred and fifteen intercollegiate athletes were grouped by high-risk (basketball, soccer, volleyball) (male=37, female=62, age=19.8±1.5 years, height=173.3±10.0 cm, weight=68.7±10.2 kg) and low-risk (baseball, softball, track and field, cross-country, wrestling) (male=79, female=37, age=19.4±1.5 years, height=176.0±10.3 cm, weight=72.6±12.3 kg) sports for ACL injury. **Interventions:** Independent variables included risk group and sex. Participants were videotaped from the frontal and sagittal views while performing three trials of a jump-landing task. Videos were later scored using the LESS, a reliable and valid 17-item binary scoring system that counts the number of errors (eg, knee valgus angle) an individual commits at initial ground contact (IGC) and maximum knee flexion (MKF) during the jump-landing task. Each trial produces a trial score, and the mean of all trial scores represents an overall score (OS), with higher scores indicating poorer jump-landing patterns. Errors for each scoring item were summed across trials for an item score (IS) and errors for all frontal and sagittal items were

summed for a frontal total error (FTE) and sagittal total error (STE) score, respectively. **Main Outcome Measures:** Dependent variables were the OS, 17 ISs, FTE and STE. Generalized linear models with two factors (risk group, sex) were utilized for group comparisons. Group differences were further analyzed using pairwise comparisons (Bonferroni), $p<0.05$. **Results:** Significant interaction effects were reported for three ISs (toe out at MKF [p=0.048], knee valgus at MKF [p=0.017], overall frontal plane displacement [p=0.021]) and for FTE (p=0.011), with high-risk females generally committing more errors than other groups. Significant main effects of risk group were reported for OS (p=0.009; high-risk=5.51±0.39, low-risk=4.97±0.24), three ISs (foot asymmetry at IGC [p=0.024; high-risk=0.71±0.10, low-risk=0.39 ±0.94], limited hip flexion at MFK [p=0.030; high-risk=0.94±0.11, low-risk=0.59±0.11], overall sagittal joint displacement [p=0.001; high-risk=2.93±0.18, low-risk=2.11 ±0.17]) and STE (p=0.033; high-risk=7.72±0.49, low-risk=6.26± 0.47), with the high-risk group committing more errors than the low-risk group. Significant main effects of sex were reported for knee valgus at IGC ($p<0.001$; females=1.25±0.12; males=0.57±0.11). **Conclusions:** Our findings suggest that high-risk sport athletes, particularly females, tend to demonstrate poorer jump-landing patterns than low-risk sport athletes. This is surprising given that high-risk sport athletes are likely more familiar with the movement pattern of a jumping-landing task than their low-risk counterparts. Future studies should determine if these differences are clinically significant (eg, increases risk for lower extremity injury).

The Reliability Of Commonly Used Wet Bulb Globe Temperature Devices

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Context: Wet Bulb Globe Temperature (WBGT) is a composite environmental measure used to estimate the effect of ambient temperature, humidity and radiation. WBGT measures are used in a variety of settings including the workplace, military and athletics. The Georgia High School Association has adopted specific rules for practice based on the WBGT reading. **Objective**: To assess the reliability of commonly used WBGT devices on different surfaces. **Design**: Observational field study. **Setting**: Artificial field turf and grass practice fields in Athens, Ga. **Equipment**: The Extech Heat Stress Meter, General Heat Index Checker, Kestrel 4400 Heat Stress Tracker, Kyoto Electronics WBGT 103 Heat Stress Checker, Quest Temp 34 and Reed Heat Index WBGT meter were assessed. The reference unit was designed to meet specifications for a WBGT monitor determined by ISO standard 7243 (ISORU). **Interventions**: WBGT devices were simultaneously tested against the ISORU for two sessions. The first session was on field turf and the second session was on grass. **Main Outcome Measures**: Data were recorded for two, 2-hour afternoon sessions, at 2 minute intervals. Data were then averaged over 14 minute periods for analysis. Mean absolute error (MAE), root mean square error (RMSE), and Pearson's correlation coefficient (r) were used to quantify instrument performance relative to the reference unit. **Results**: The overall mean and standard deviation for the ISORU was 27.20ºC and 2.07ºC. The mean and (average mean difference from the ISORU) was lowest in the Quest Temp 34 27.37ºC (0.17ºC) and Extech Heat Stress Meter 26.90ºC (0.30ºC), followed by the Reed Heat Index WBGT monitor 26.83ºC (0.37ºC) and Kyoto Electronics WBGT 103 Heat Stress Checker 26.45ºC (0.75ºC). The Kestrel 4400 28.23ºC (1.03ºC) and General Heat Index Checker 25.83ºC (1.37ºC) were the farthest from the ISORU. All units demonstrated excellent correlation ($r>0.96$) compared to the ISORU. The Quest Temp 34 and Extech Heat Stress Meter units performed the best with the lowest MAE (RMSE) values of 0.19˚C (0.27˚C) and 0.46˚C (0.56˚C) respectively, followed by the Reed Heat Index WBGT meter and Kyoto Electronics WBGT103 units with values of 0.81˚C (0.93˚C) and 0.64˚C (0.85˚C). The Kestrel 4400 and General Heat Index Checker units had the largest MAE and RMSE values of 1.05˚C (1.02˚C) and 1.37˚C (1.42˚C), respectively. **Conclusions:** All six units tested performed well compared to the ISORU. Overall the Quest Temp 34 performed best with the lowest MAE and RMSE of the units assessed. However, all six units had excellent correlations ($r>0.96$) and were within 1.42˚C of the ISORU. We conclude the units are each reliable devices for monitoring WBGT on both artificial and grass surfaces. Athletic trainers should evaluate each unit to determine the best unit based on their individual psychometric properties.

The Validity Of Head Impact Indicators To Positively Predict Concussion

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Context: Commercially available helmet- and chinstrap-based head impact indicators purportedly measure resultant linear head acceleration (RLHA), measured in gravities (g), or the Head Injury Criterion (HIC), and alert coaches and athletes when head impacts exceeding predetermined tolerance thresholds are sustained during sports participation. These thresholds vary among currently available head impact indicators and are widely unsupported by the research literature. **Objective:** To determine the sensitivity, specificity, and positive predictive value (PV+) of head impact indicators. We hypothesized variable sensitivity, high specificity, and poor PV+ of head impact indicators. **Design:** Prospective cohort. **Setting:** Field setting. **Patients or Other Participants:** Convenience sample of 184 male (age=19.2±1.4yrs) football players representing all playing positions recruited from one Division I program. **Interventions:** Head impact biomechanics for 283,348 impacts were collected using Head Impact Telemetry System instrumentation during practices and competitions over an 8-year period (preseason, fall, and spring seasons). During this time, a team of physicians, athletic trainers, and clinical researchers made concussion diagnoses based on a comprehensive multi-faceted concussion management program (n=24). We dichotomized each impact based on concussion diagnosis (yes=24/no=283,324). We also dichotomized RLHA and HIC based on whether thresholds employed by commercially available head impact indicators were exceeded: RLHA of 50 g, 75 g, or 100 g; and HIC value of 240. We used frequency analyses to compute the sensitivity, specificity, and PV+. **Main Outcome Measures:** Frequencies of dichotomized injury diagnosis, RLHA and HIC. **Results:** Based on our independent head impact biomechanical data, head impact indicators employing a 50 g impact threshold would be 95.8% (95%CI: 79.8–99.3) sensitive based on 24 injuries and 90.4% (95%CI: 90.3–90.5) specific, but possess 0.1% PV+ based on 27,148 impacts >50 g. At a 75 g threshold, we observed 75.0% sensitivity (95%CI: 55.1–88.0) and 97.0% specificity (95%CI: 96.9–97.0), but only 0.2% PV+. Employing a 100 g threshold, we observed 45.8% sensitivity (95%CI: 27.9–64.9) and 99.0% specificity (95%CI: 99.0–99.1), with a 0.4% PV+. Lastly, head impact indicators would be 20.8% (95%CI: 9.2–40.5) sensitive and 99.3% (95%CI: 99.3–99.4) specific, with a 0.3% PV+ if a HIC of 240 were to be employed as an impact indicator threshold. **Conclusions:** While specificity appears high using these indicator thresholds, clinicians should consider the very low PV+ and variable sensitivities associated with utilizing theoretical impact thresholds for removal from play. Our findings suggest that conducting an examination based on head impact indicators alone would result in an extremely high number of unnecessary athlete evaluations. We only studied the thresholds employed by commercially available head impact indicators as a means of exploring whether the concept has any clinical utility for athletic trainers. Future studies investigating head impact indicators' actual measurement validity should be pursued. Study funded in part by the Centers for Disease Control and Prevention and the National Operating Committee on Standards for Athletic Equipment.

Kinesiophobia And Fear-Avoidance Beliefs Are Greater In Those With Chronic Ankle Instability

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Context: Individuals with chronic ankle instability (CAI) have exhibited decreased health-related quality of life based on regional and global measures of health. Despite these findings, the extent to which these individuals display deviations in mental aspects of function such as kinesiophobia and fear-avoidance belief is unknown. **Objective:** To determine if measures of kinesiophobia and fear-avoidance belief differ between individuals with and without CAI and correlate with injury characteristics that quantify the magnitude of CAI. **Design:** Case-control. **Setting:** Laboratory. **Patients or Other Participants:** Sixteen participants with CAI (3 males, 13 females, age=21.9±2.6 years, height=170.8±9.8cm, mass=70.1±13.3kg) were gender and age matched to sixteen healthy participants with no history of ankle sprain (3 males, 13 females, age=22.6±1.7 years, height= 166.4±8.9cm, mass= 63.8±12.1kg). Participants were included in the CAI group if they reported at least one ankle sprain, two episodes of "giving way" in the past three months, and answered "yes" to five or more questions on the Ankle Instability Instrument. **Interventions:** Participants reported to the laboratory for a single testing session. Participants in both groups completed the Tampa Scale of Kinesiophobia-11 (TSK-11) and Fear-Avoidance Beliefs Questionnaire (FABQ). The TSK-11 contains 11 items with 4-point likert scales. The FABQ contains a total of 11 items with 6-point likert scales. Individuals in the CAI group also reported the number of previous ankle

sprains (PAS), the number of episodes of "giving way" in the past 3 months (EGW), and completed the 8-item Foot and Ankle Ability Measure-Sport (FAAM-Sport). **Main Outcome Measures:** TSK-11 scores range from 11-44 with higher scores indicating a greater level of kinesiophobia. FABQ scores range from 0-66 with higher scores indicating increased fear-avoidance belief. Dependent variables included the TSK-11 and FABQ scores and the independent variable was group (CAI, healthy). Independent samples t-tests were used to examine group differences in TSK-11 and FABQ scores. Pearson-product moment correlations (r) were calculated to determine if TSK-11 and FABQ scores were related to PAS, EGW, or FAAM-Sport scores (%) in the CAI group. Alpha level was set a priori at $p<0.05$ for all analyses. **Results:** Significant group differences were identified for the TSK-11 (CAI=18.1±4.0, Control=13.5±3.0, p=0.004) and FABQ (CAI=17.9±9.7, Control= 1.5±2.6, p<0.001). Within the CAI group, TSK-11 scores were significantly correlated to PAS (4.5±3.8; r=0.52, p=0.04), but not EGW (7.2±7.4; r=-0.49, p=0.054) or FAAM-Sport scores (76.2±18.1%; r=-0.13, p=0.62). The FABQ was not significantly correlated to PAS (r=0.01, p=0.98), EGW (r=0.08, p=0.77) or FAAM-Sport scores (r= -0.18, p=0.51). **Conclusions:** Individuals with CAI experience greater kinesiophobia and fear-avoidance beliefs compared to healthy controls. Also, individuals with CAI with a greater number of sprains report increased levels of kinesiophobia. These findings suggest that measures of kinesiophobia and fear-avoidance belief should be examined during the rehabilitation process of individuals with CAI.

Increase In Humeral Retrotorsion Accounts For Age-Related Increase In Glenohumeral Internal Rotation Deficit In Youth/Adolescent Baseball Players

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Context: Glenohumeral internal rotation deficit (GIRD) of the throwing limb relative to the non-throwing limb has been linked to shoulder and elbow injury in baseball players. While it has been demonstrated that GIRD increases during adolescence, it remains unclear whether this change is due to increases in humeral retrotorsion (osseous) or soft tissue tightness of the throwing limb. Measuring humeral retrotorsion along with shoulder internal rotation range of motion (IRROM) allows us to differentiate osseous vs. soft tissue contribution to GIRD in baseball players of different ages, as well as compare GIRD between age groups once it has been corrected for humeral retrotorsion. **Objective:** The purpose of this study was to evaluate the influence of age group on GIRD, humeral retrotorsion, and corrected-GIRD in baseball players. **Design:** Cross-Sectional. **Setting:** Field Laboratory. **Patients or Other Participants:** Four groups of baseball players (n=287) participated: 1) youth (6-10 year olds) (n=52, age= 8.3±1.3yrs, height=133.7±11.1cm, mass=33.6±8.6kg), 2) junior high (11-13 year olds (JH)) (n=52, age =11.9±0.9yrs, height=149.9±17.8cm, mass=47.2±9.7kg), 3) junior varsity (14-15 year olds (JV)) (n=70, age=14.6±0.5yrs, height =176.3 ±5.7cm, mass=69.6±12.9kg), and 4) varsity (16-18 year olds) (n=113, age=16.9±0.8yrs, height =180.3± 6.6cm, mass=78.0±11.4kg). **Interventions:** IRROM and humeral torsion were measured bilaterally using a digital inclinometer and diagnostic ultrasound, respectively. **Main Outcome Measure:** A 3-trial mean was calculated for IRROM and humeral torsion measures. Corrected-IRROM was calculated as the amount of available IRROM once humeral torsion was accounted for. GIRD and corrected-GIRD side-to-side differences were calculated as the angular difference in IRROM and corrected-IRROM. Three separate one-way ANOVAs were used to compare GIRD, humeral retrotorsion, and corrected-GIRD between age groups. **Results:** There were significant group difference in GIRD ($F_{3,284}=8.957$, $p<0.001$) and humeral torsion side-to-side difference ($F_{3,284}=9.688$, $p<0.001$), but not in Corrected-GIRD ($F_{3,284}=1.136$, $p=0.335$). GIRD was greater in varsity participants compared to youth (mean difference (md)=5.05°, p=0.002) and JH (md=4.95°, $p=0.002$) participants, and in JV participants compared to JH (md=5.36°, $p=0.002$) and youth (md=5.47°, $p=0.002$) participants. Humeral torsion was greater in varsity participants compared to youth (md=8.79°, $p<0.001$) and JH (md=5.52°, $p=0.014$) and JV compared to youth participants (md=7.88°, $p=0.001$). **Conclusions:** As demonstrated previously, GIRD increased with age in youth/adolescent baseball players. We also observed that humeral retrotorsion increased with age, while the torsion corrected GIRD remained unchanged. This result indicates that the age-related increase in GIRD is primarily attributed to increase in humeral retrotorsion, and not soft tissue tightness. Our study suggests that the most significant alterations in torsional side-to-side differences occur between youth and JV participants (6-16), suggesting that this period of physical maturation should be further investigated in relation to the development of risk factors for shoulder and elbow injury. **Acknowledgements:** Funding provided by NIH-NIAMS:R03AR055262.

Effect Of Strength-Training Protocols On Strength And Dynamic Balance In Participants With FAI

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Context: While lateral ankle sprains are common in sport and can often lead to functional ankle instability (FAI), strength-training rehabilitation protocols may improve the deficits of FAI. **Purpose**: To determine the effects of strength-training protocols on strength and dynamic balance in participants with FAI. **Design**: A randomized controlled clinical trial. **Setting:** University Athletic Training Research Laboratory. **Patients and Other Participants:** Thirty-nine participants (17 males, 22 females, 19.72±1.96 years, 173.54±9.21 cm, 70.68±12.89 kg) with FAI volunteered to participate in the study. The Ankle Instability Instrument determined the presence of FAI and subjects were excluded if they had a history of lower extremity fracture/surgery or a balance disorder. **Interventions:** Participants were pre-tested for strength and dynamic balance. Strength was assessed isometrically using a handheld dynamometer (Lafayette Manual Muscle Tester, Lafayette Instruments Co) in four directions: dorsiflexion, plantarflexion, inversion, and eversion. Three trials of each direction were performed. Dynamic balance was assessed using the Y-balance test kit (Functional Movement Systems, Inc). Participants completed three reach trials in each direction: anterior, posterolateral and posteromedial. Participants were then randomly assigned to either the resistance band protocol (RBP), Proprioceptive Neuromuscular Facilitation strength protocol (PNF), or control group (CON). Participants in the RBP and PNF groups completed their respective protocols 3x/week for 6 weeks. Participants in the CON group did not attend rehabilitation sessions. All subjects were post-tested at the end of six weeks in the same manner as the pre-test. **Main Outcome Measures:** Dorsiflexion, plantar-flexion, inversion, and eversion isometric strength (kg) and Y-balance test (composite score of three directions standardized to limb length in cm). Maximum values were used for statistical analysis. Separate RMANOVA was completed for each dependent variable and Bonferroni post hoc test was conducted on any significant findings. Alpha level was set a $p<0.05$. **Results:** Both the RBP and PNF groups significantly improved between pretest and posttest in isometric strength. In the RBP group, dorsiflexion improved by 23% ($F_{2,36}=3.43$, $p=0.043$) and plantar-flexion improved by 15% ($F_{2,36}= 3.48$, $p=0.041$) over the training period. For inversion strength, the RBP group improved by 29% and the PNF group improved by 28% following training ($F_{2,36}=6.14$, $p=0.005$). Similarly for eversion strength, the RBP group improved by 28% and the PNF group improved by 31% ($F_{2,36}=7.44$, $p=0.002$). There were no significant strength improvements in the CON group between the pretest and posttest ($p>.05$). There were no significant differences in Y-balance test performance ($p=0.08$) in any group. **Conclusion:** Both rehabilitation protocols were effective at improving isometric ankle strength following the six weeks. Neither rehabilitation protocol created an improvement in dynamic balance.

Shoulder Flexion Torque Is Augmented By A Volitional Abdominal Contraction

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Context: Increased activation of the abdominal musculature increases active stiffness of the trunk and enhances core stability. A strong and stable core is associated with decreased injury and improvements in performance. Further, a stable core provides a solid base thereby theoretically enhancing extremity function. Contraction of the abdominal musculature during functional activities however generally occurs automatically at a subconscious level. It is unclear if an individual is able to produce a greater amount of extremity torque while performing a superimposed volitional contraction of the abdominals. **Objective**: To determine if shoulder torque values were different when subjects performed a maximal voluntary isometric contraction (MVIC) of the shoulder flexors with and without a volitional isometric contraction of the abdominals. We hypothesized participants would be able to generate a greater amount of isometric shoulder flexion torque (ISFT) when the abdominals were consciously activated. **Design**: Quasi-experimental repeated measures. **Setting**: Research laboratory. **Patients or Other Participants**: A convenience sample of 30 healthy, recreationally active college aged students (age=21.9±1.2years; weight =75.2±16.3kg; height= 174.7±9.4cm) participated. **Interventions**: Participants completed a 5-minute warm up on an upper body ergometer (Monark; Vansbro, Sweden) at a self-selected pace. Next, using a standardized and previously reported protocol, surface EMG (sEMG) was captured from the right and left rectus abdominis (RA) using a telemetry system (Noraxon;

Scottsdale, AZ) that was interfaced with a commercially available software acquisition system (Run Technologies; Laguna Hills, CA) and personal computer (Dell; Austin, TX). Collection of RA sEMG was essential to determine if RA percent activation was different between test conditions. Subjects then completed three repetitions of an isometric abdominal crunch to establish an MVIC of the RA for normalization. Then in a counterbalanced order using their dominant upper extremity, subjects completed three trials of maximal isometric shoulder flexion at 90 degrees using an isokinetic dynamometer (Biodex; Shirley, NY) with and without a volitional contraction of the abdominals. **Main Outcome Measures**: Dependent variables included RA percent activation and ISFT. We used paired t-tests to determine if RA percent activation and ISFT values differed between conditions (contracted; relaxed). **Results:** Percent activation of the RA was greater when subjects volitionally contracted their abdominals (15.8±12.7%) compared to the relaxed condition (6.3±4.8%) (Pd"0.001). ISFT was greater when the abdominals were actively contracted (44.6±18.9N*m) compared to ISFT when the abdominals were recruited subconsciously (30.7±15.7N*m) (Pd"0.001). **Conclusions**: Subjects are able to volitionally recruit greater amounts of RA sEMG compared to the percent activation that automatically occurs while performing an upper extremity task. ISFT values at 90 degrees of flexion are greater when a subject volitionally superimposes a contraction of the abdominals when compared to ISFT when the abdominals are solely recruited in a subconscious fashion.

Double Legged Squat Mechanics Influence Medial Knee Displacement

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Context: Dynamic knee valgus or medial knee displacement (MKD) is a theorized risk factor for chronic and acute knee injuries. MKD is the medial collapse of the knee and is a combination of tibial and femoral motions. However, it is unclear what specific kinematic components specifically contribute to MKD during the double legged squat (DLS). This information could be valuable to clinicians as they design intervention strategies to improve performance and decrease injury risk. **Objective:** The purpose of this investigation was to examine how kinematics of the lower extremity influence MKD during the DLS. **Design:** Cross-sectional. **Setting:** Laboratory. **Patients or Other Participants:** Eighty three volunteers with no history of lower extremity injury (171.3±9.2cm, 69.2±12.2kg, 20.3±1.5yrs, 21 Males, 62 Females) completed this study. **Interventions:** All individuals completed five trials of a DLS from a standardized start position: feet should width apart, toes straight ahead, with the hands over the head. Subjects were instructed to squat like they were sitting in a chair to a deep but comfortable depth and in a controlled manner. The dominant limb was used for testing which was defined as the limb used to kick a ball maximal distances. **Main Outcome Measures:** Peak kinematics associated with ACL loading of the hip (flexion, adduction, and internal rotation), knee (flexion, valgus, and internal rotation), and trunk flexion were used as predictor variables while MKD during the DLS was used as a criterion variable. MKD was calculated using the electromagnetic tracking system and was defined as displacement of the knee center in the frontal plane (cm). Peak values were obtained for each trial and the average was used in the analyses. Separate forward stepwise regressions were performed for each gender to determine the influence of lower extremity kinematics on MKD. All statistical analyses were performed in SPSS with significance set a priori at $P < 0.05$. **Results:** In females, peak hip adduction angle (5.1±4.4°) and peak knee valgus angle (-8.4±9.1°) explained 29% of the variance in MKD (1.1±1.1 cm, R^2=0.29, P<0.001). In males, 22% of the variance in MDK was explained by peak hip flexion angle (-115.2±11.1°) during the DSL (1.0±1.0 cm, R^2=0.22, P=0.03). **Conclusions:** Kinematics contributing to MKD differed by gender. MKD appears to be related to frontal plane hip control in females; however, sagittal plane hip control influences MKD in males. Clinicians should consider these relationships when designing interventions to reduce MKD. Other factors not assessed in this study most likely account for some of the unexplained variance in the position of MKD including range of motion restrictions or static postural alignment. Funding: Virginia Horne Henry Fund and the Wisconsin Athletic Trainers' Association.

Interactive Effects Of Body Position And Resistance On Muscle Activation And Cardiorespiratory Response During Spinning®

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Context: Spinning® is used during rehabilitation to maintain cardiorespiratory fitness and muscle function. Intensity is the major factor affecting these variables and is controlled by body position (POS) and perceived resistance level (RES). **Objective:** To examine the effect of 3 POS and 4 RES on muscle activity of the vastus lateralis (VL) and cardiorespiratory response during Spinning®. **Design:** Within-subjects repeated measures design. **Setting:** Laboratory of Neuromuscular Research and Active Aging **Patients or Other Participants:** Eleven healthy, recreational athletes with at least 6 months Spinning® experience (height=1.68±.09 m, mass=65.8±11.3 kg, age=24.4±6.3 years). **Interventions:** Following and 8h fast, electromyographical normalized root mean square (nRMS) of the right VL and breath-by-breath data were recorded during 12 (3POS x 4RES) three-minute randomly assigned Spinning® conditions on four testing days. POS included seated, running, and standing climb (SC), and RES used 4 ranges of the 15-point Borg Perceived Exertion Scale (RPE 6-9, 10-13, 14-6, 17-20). RMS was normalized for each testing session using maximal voluntary isometric leg extensions (hip and knee at 90° of flexion). **Main Outcome Measures:** Dependent variables included nRMS, heart rate (HR), VO_2 relative to body weight (VO_{2rel}), and respiratory exchange ratio (RER) during each condition. A 3(POS) x 4(RES) within-

subjects ANOVA with Bonferroni post-hoc analysis was performed for each variable. **Results:** A significant POS x RES interaction was observed for nRMS (p=.034). For the seated position, RPE 10-13 (0.26±0.08), 14-16 (0.39±0.15), and 17-20 (0.51±0.14) were significantly greater than RPE 6-9 (0.09±0.08) and RPE 17-20 was significantly greater than RPE 10-13. For running and SC, RPE 17-20 (0.50±0.15 and 0.49±0.13) was significantly greater than RPE 6-9 (0.23± 0.08 and 0.20±0.07) and 10-13 (0.25±0.06 and 0.27±0.08). Additionally for SC, RPE 14-16 (0.37±0.15) was greater than RPE 6-9. When the post-hoc analysis was performed across RPE levels, the only significant difference detected was between the running and seated conditions at RPE 6-9. A significant main effect was observed for POS and RES for VO_{2rel} (p<.02). VO_{2rel} was greater for the running (28.9±2.2 ml•kg^{-1}•min^{-1}) and standing climb positions (26.8±1.7 ml•kg^{-1}•min^{-1}) than for the seated POS(23.5± 2.0 ml•kg^{-1}•min^{-1}) and greater for RPE 14-16 and 17-20 (31.2±2.4 and 34.9±2.6 ml•kg^{-1}•min^{-1}) than RPE 6-9 and 10-13 (16.5±1.8 and 22.9± 1.9 ml•kg^{-1}•min^{-1}) and RPE 10-13 was significantly greater than 6-9 (p<.01). RER was affected by RES only (p<.001), while a significant POSxRES interaction was observed for HR (p=.024) where HR patterns did not match VO_{2rel} patterns. **Conclusions:** VL activity patterns consistently increased with RES regardless of POS. The SC and running POS can be expected to produce higher cardiorespiratory responses than seated across RES levels. HR appears to be ineffective as a monitoring method for cardiovascular effort.

A Comparison Of Body Fat, Lean Muscle Mass And Max Vertical Jump Height In Olympic Level Athletes

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Context: Anecdotal evidence among coaches suggests a relationship between body composition and performance despite little research examining this connection. Athletic performance is often contextually linked to body fat and lean muscle mass scores, particularly when scores may be subjective and associated with visual appeal. Body fat is often measured using skin fold calipers, and is prevalent in sports that are considered aesthetic or have weight categories. The reliability of body mass index (BMI) in elite athletes is low due to athletes' higher percentages of lean muscle mass. However, Dual-Energy X-ray absorptiometry (DEXA) has been shown to provide an accurate assessment of body composition. **Objective**: The objectives were two fold 1) Determine if a three trial, three site pinch caliper test and DEXA yield similar results. 2) Determine if lean muscle mass and percent body fat is correlated with max vertical jump height (measure of power output). **Design**: Cross-sectional **Setting:** Outpatient Orthopedic Clinic. **Patients or Other Participants:** 25 Olympic level athletes (ages 18-27) volunteered that participated in Olympic weight lifting (men and women), Greco-Roman (men) or freestyle wrestling (women), short track speed skating (men and women). Males (N=12) mean height was 164.17cm±5.08 and weight was 69.1kg±15.9. Females (N=13) mean height 172.76cm±9.53, and weight was 82.83kg±17.57. **Interventions:** The independent variable was level of athlete participation. Body fat percentages calculated using Lohman's validated method included a body fat caliper three trial three site pinch (abdominal, subscapular and triceps) and was compared to DEXA measures. All body fats were measured on the right side and by the same examiner. Vertical jump scores were recorded for the best of three max attempts using the Vertec following validated standardized warm-up procedures. **Main Outcome Measures:** The dependent variables were body fat percentages via caliper and DEXA, body mass index (BMI) and maximum vertical jump. Analyses included a paired t-test and Pearson correlations with a priori alpha level set at P=.05. **Results:** A paired t-test showed no significant difference between DEXA (mean 20.64±10.74) and caliper (mean 20.03±7.96) testing (P=.559). Pearson Correlations revealed lean muscle mass was strongly correlated with DEXA (mean 60.87±14.75) and caliper calculations (mean 60.87±14.75). BMI (26.52 ±4.03) was low to moderately correlated with DEXA percent body fat (P=.089, r=.347). DEXA percent body fat was moderately inversely correlated with jump height (P=.004, r=-.565) and moderately correlated with lean muscle mass (P=.013, r=.501). **Conclusions:** Body fat calipers are an accurate substitute for DEXA measures, while BMI was not significantly correlated with DEXA in this population. Individuals who had lower body fat scores, and more lean muscle mass were more likely to score higher on the max vertical jump.

Lower Extremity Functional Contributions To Dynamic Postural Control

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Context: A lack of standardized clinical tools exists for musculoskeletal injury risk and functional performance assessment. The single leg anterior reach (SLAR) component of the star excursion balance test is a commonly utilized clinical option to assess dynamic postural control and ankle sprain injury risk. However, the contributions of ankle joint range of motion and single leg dynamic function to SLAR postural control is unknown. **Objective:** To determine the relationship between various aspects of functional performance and dynamic postural control and the best predictors of dynamic postural control. **Design:** Descriptive laboratory study **Setting:** Biomechanics research laboratory **Participants:** 41 male NCAA Division I lacrosse athletes (19.6±1.17 years, 1.83±0.08 m, and 84.7±8.6 kg) **Interventions:** A comprehensive functional performance assessment was completed prior to the regular season consisting of left and right SLAR for dynamic balance, single leg hop (SLHOP) for single leg power and landing control, two measurements of dorsiflexion range of motion (lunge and kneeling), trunk endurance(back extension and side bridges for time) and hip strength (isometric flexion, extension, abduction, adduction). **Main Outcome Measures:** Pearson correlations were performed to assess the relationship between SLAR and SLHOP, dorsiflexion, trunk endurance and hip strength with an alpha level set at .05. A regression model was completed to determine the best predictors of SLAR performance. **Results**: Left SLAR was correlated with left SLHOP (.322, p=.04), lunge dorsiflexion (.565, p<.001) and kneeling dorsiflexion (.647, p<.001). Right SLAR was correlated with right single leg hop distance (.426, p<.006), lunge dorsiflexion (.655, p<.001) and kneeling dorsiflexion (.717, p<.001). Trunk endurance and hip strength were not correlated with SLAR performance. The best regression model to predict SLAR performance included kneeling dorsiflexion and SLHOP as significant predictors (Right: r^2 .50, p<.001, Left: r^2 .55, p<.001). The regression model indicated that the variance of SLAR performance is explained heavily by kneeling dorsiflexion (Right: r^2 .42, p<.001, Left: r^2 .51, p<.001). The inclusion of the additional lunge dorsiflexion measure did not add to the model as the correlation between these two measures was very high (Right: .903, p<.001, Left: .889, p<.001). Trunk endurance and hip strength were not significant predictors in the model. **Conclusions:** The results of this study show that SLAR performance is highly related to kneeling weight bearing dorsiflexion and lunge dorsiflexion range of motion and moderately related to SLHOP performance. This indicates that the SLAR clinical assessment of postural control is moderately dependent on closed chain dorsiflexion range of motion. Clinicians assessing dynamic balance should consider dorsiflexion range of motion as a possible limiting factor. Other variables such as postural control and eccentric muscle strength may also play a role in SLAR performance that is not captured with dorsiflexion motion or hop performance.

Effect Of Diminished Plantar Cutaneous Sensation And Foot Type On Static Postural Control

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Context: Plantar cutaneous sensation and different foot types may influence the regulation of postural control. However, it is unclear whether different foot types are associated with variances in postural control before and after removal of plantar cutaneous sensation. Objective: To determine if different structural foot types influence postural control after diminished plantar cutaneous sensation. Design: Case controlled study. Setting: Laboratory. Patients or Other Participants: A total of 39 healthy, young adults (age: 24.67±2.39 years; height: 173.17±8.57 cm; weight: 69.05±13.78 kg) were recruited. There were 18 pronated, 35 neutral, and 25 supinated feet. Interventions: We classified foot type as pronated (e”10mm), neutral (5-9mm), or supinated (d”4mm) by navicular drop test measures. Subjects placed the plantar surface of both feet in an ice bath for 10 minutes. Before and after ice-immersion, subjects performed three trials of a 10 seconds single-leg stance balance test with their eyes closed while standing on top of an Acusway forceplate (AMTI INC, Watertown, MA). Main Outcome measures: Center of pressure x range (RangeX); y range(RangeY); x velocity(VelocityX); y velocity (VelocityY); x standard deviation (SDx); y standard deviation(SDy); x time to boundary (TTBx); y time to boundary(TTBy); x mean time to boundary(mean TTBx); y mean time to boundary(mean TTBy); x standard deviation time to boundary(SD TTBx); and y standard deviation time to boundary(SD TTBy) were measured to quantify postural control. Group (foot type) by time (plantar sensation) mixed

model two-way repeated measures of ANOVA was used to analyze differences between foot types and plantar cutaneous sensation. **Results**: A significant main effect for time was found in SDy ($F_{1,75}$=9.57; P=.00). Post hoc analysis showed that diminished plantar cutaneous sensation resulted in increased standard deviation (SD) of center of pressure (CoP) in A-P direction (pre: 1.13±.28; post: 1.22±.29; P=.00). A significant main effect for time was found in RangeY ($F_{1,75}$=9.07; P=.00). Also diminished plantar cutaneous sensation resulted in increased range of CoP in the A-P direction (pre: 5.53±1.34; post: 5.97±1.44; P=.00). A significant main effect for time was found in VelX ($F_{1,75}$=4.00; P=.05). Diminished plantar cutaneous sensation also resulted in decreased velocity of CoP in M-L direction (pre: 5.11±1.18; post: 4.96±1.22; P=.05). Interestingly, the main effect for foot type and interaction did not reveal significant differences and all time to boundary variables did not have significant differences. **Conclusions**: After plantar cutaneous de-sensitization, there was a deficit in A-P directional postural control and improvement in M-L directional postural control. This indicates that mechanoreceptors located in the deep plantar surface of the foot play an important role to control posture.

Postural Control Differences Between Adolescent And Collegiate Male Athletes Using The Stability Examination Test

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Context: Postural control is an essential component of athletic participation and has roles in both musculoskeletal rehabilitation and concussion evaluation. The Stability Examination Test (SET) aims to objectively analyze an athlete's balance and postural control through measurement of sway velocity (SV) on a portable force platform. To date the SET has been primarily used in collegiate athletes, however the development of postural control progresses into adolescence, due to continued neural development, strength gains, and muscle activation. **Objective**: To determine whether postural control differences exist between adolescent and collegiate populations using the SET protocol. **Design**: Cross-sectional. **Setting**: High school and collegiate athletic training facilities and a research laboratory. **Patients or Other Participants**: Convenience sample of 35 adolescent (age=11.1±2.1 years, height=149.7±15.7cm) and 133 collegiate (age=19.4±1.3 years, height=181.3±9.0cm) male athletes. **Interventions**: The independent variable was group; adolescent (9-15 years) vs. college (18-22 years). All participants completed the SET, which involved 6 20-second balance tests with eyes closed, under the following conditions: double-leg firm (DFi), single-leg firm (SFi), tandem firm, (TFi), double-leg foam (DFo), single-leg foam (SFo), and tandem foam (TFo). **Main Outcome Measures**: The dependent variable was sway velocity (SV) for each of the 6 SET conditions. A composite SET SV variable was also analyzed. SV (deg/sec) is defined as the ratio of the distance traveled by the center of gravity to the time of the trial. A higher score indicates poorer balance. A 2 (group) by 6 (condition) repeated measures analysis of variance was used to evaluate differences in SV. An independent t-test assessed differences in the composite SV variable. **Results**: The interaction for SV was significant (P=.028) and there were significant main effects for group (P=.001) and condition (P<.001). The composite SV was significantly higher (P=.023) in the adolescents (3.29±1.21 deg/sec) compared to the college athletes (2.79±0.60 deg/sec). Post-hoc analysis of the interaction revealed that the adolescents had significantly higher SV for the single-firm (3.22±1.78 vs. 2.16±.90 deg/sec) and single-foam (5.25±1.99 vs. 4.44±1.25 deg/sec) conditions, with no significant differences among the other conditions. The significant main effect for condition revealed differences between all 6 conditions with DFi (0.75±0.22 deg/sec) < TFi (1.78±0.97 deg/sec) < SFi (2.367±1.17 deg/sec) < DFo (2.84±0.88 deg/sec) < SFo (4.85±1.47 deg/sec) < TFo (5.19±2.26 deg/sec). **Conclusions**: Our results indicate that the adolescent population had an overall higher composite SV, indicating decreased postural control. The differences were more profound on the conditions that required a single-limb stance, perhaps resulting from a lack of lower limb strength, in addition to postural instability. Future studies should evaluate whether these differences exist in females and at what age do adolescents resemble adults with this measure of postural control.

Normally-Occurring Ankle Range Of Motion And Dynamic Postural Control Asymmetries In Healthy Collegiate Cross-Country Runners

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Context: Cross-country running requires participants to constantly adapt to changing surfaces over the course of training and racing. Lower extremity injuries are widespread in this sport. Side-to-side asymmetries in ankle dorsiflexion (DFROM) and the anterior reach distance of the Star Excursion Balance Test (ANTSEBT) have been identified as risk factors for lower extremity injury in other sports, but no evidence exists about the normally occurring asymmetries in these measures for collegiate cross-country runners. By examining the normally occurring DFROM and ANTSEBT asymmetries, we can build a better understanding of their utility as screening tools in this population. **Objective:** To determine the normally occurring DFROM and ANTSEBT asymmetries in healthy collegiate cross-country runners. **Design:** Cross-sectional design. **Setting:** Athletic Training Room. **Participants:** 25 healthy Division I collegiate cross-country runners (11 Females, 14 Males, Age: 19.9±1.5 yrs, Height: 1.7±0.4m, Mass: 64.1± 13.0kg) who were free from any lower extremity injury for at least 6 weeks participated. **Interventions:** All testing procedures were performed on both limbs of each participant. Participants performed 3 trials of maximum reach in the ANTSEBT on each limb. The weight-bearing lunge test was used to measure DFROM. Subjects performed 3 trials of the WBLT in which they kept their test heel firmly planted on the floor while they flexed their knee to the wall. Maximum dorsiflexion was defined as the distance from the great toe to the wall based on the furthest distance the foot was able to be placed without heel-lift while the knee was able to touch the wall. Each participant performed 4 practice trials of the ANTSEBT and 1 for the WBLT for each limb. ANTSEBT reach distance and WBLT distance were recorded in cm. **Main Outcome Measures:** The mean of the 3 trials for each variable was calculated for each limb. Limits of agreement analysis (LoA) assessed the level of asymmetry between limbs for the ANTSEBT and DFROM. Pearson correlation determined the relationship between asymmetries on these two measures. Alpha level was set a priori at $p<0.05$. **Results**: For DFROM (right: 11.4±3.0 cm, left: 11.7±4.0 cm), the LoA indicated there was an average mean difference of 0.3±2.2cm between limbs. The 95% confidence limits around the mean difference revealed DFROM asymmetries up to 4.3 cm bilaterally. For the ANTSEBT (right: 68.2±7.0cm, left: 68.2±7.4 cm) there was an average mean difference of 0.0±5.3 cm between limbs with the 95% confidence limits of ANTSEBT asymmetries up to 10.4cm bilaterally. There was a significant relationship between the asymmetry of WBLT and ANTSEBT ($r=0.51$, $r^2=0.26$, $p=0.01$). **Conclusion:** There are normally occurring asymmetries in DFROM and ANTSEBT in collegiate cross-country runners. Differences beyond 4.3 cm of DFROM or 10.4 cm on the ANTSEBT may be indicative of pathological asymmetries in this population.

Effect Of Body Composition On Changes In Biomechanics And Performance During An Exercise Challenge

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Context: During intermittent exercise decrease in neuromuscular control is thought to contribute to an increased risk of injury as exercise progresses. As individuals with less lean body mass per total body mass (LBM:TBM) require greater muscle activation to control the same body weight compared to those with higher LBM:TBM, it has been hypothesized that greater lean mass may provide protection to the joint during dynamic tasks. However, whether greater LBM:TBM protects against the fatigue-induced biomechanical changes has not been directly examined. **Objective:** To compare individuals stratified into above average and below average LBM:TBM on performance and landing biomechanics during an intermittent exercise protocol (IEP). **Design:** Descriptive cohort. **Setting:** Research laboratory. **Participants:** Fifty-nine (29F, 30M;20.4±2.2yrs, 173.3± 9.0cm, 68.7±10.5kg) healthy, active participants. **Interventions:** Males and females were equally stratified into above and below average LBM:TBM and participated in an individualized 90 minute IEP that included 7 varying running intensities. Performance measures and biomechanical data were assessed during a 45cm drop jump (DJ) landing protocol performed before exercise (Pre) and immediately after two 45-minute bouts of running (Post45 and Post90). **Main Outcome Measures:** Performance was monitored via a rating of perceived exertion (RPE) scale, counter-movement jump height in meters (CMJ), and sprint speed in

m/s (SS). To assess biomechanical changes, kinetic and kinematic data were collected and used to calculate hip, knee, and ankle energy absorption ($JxBW(N)^{-1}xHt(m)^{-1}$) from foot contact until peak knee flexion. Separate 2 (group) x 3 (time) repeated measures ANOVA's examined differences in CMJ, RPE, SS, and energy absorption. Results: RPE increased [Pre (10.09± 2.11)<Post45 (13.98±2.06)<Post90(14.96±2.39); P<0.001] and SS decreased [Pre (4.80±0.36)>Post45(4.68±0.42)>Post90 (4.57± 0.44); P<0.001] at each time point regardless of group. Energy absorption at the knee decreased for both groups at the Post45 and Post90 compared to Pre [Pre(-0.090 ±0.020)>Post45(-0.085± 0.022), Post90(-0.086± 0.022); P=0.018]. While those with greater LBM:TBM reported less exertion (12.3 vs. 13.6; P=0.004), jumped higher (0.38 vs. 0.31 m; P=0.003), and sprinted faster (4.80 vs. 4.57 m/s; P=0.024) there were no group differences by time (P-value range: 0.51–0.93). Hip, knee, or ankle energy absorption did not differ by group (P-value range: 0.14-0.75) or group by time (P-value range: 0.46–0.77). There was no main effect or interaction for CMJ (P>0.05). **Conclusions:** Regardless of LBM:TBM, RPE increased, SS decreased, CMJ did not change, and energy absorption at the knee decreased after 45 minutes of exercise, where it remained after 90 minutes. While those having greater LBM:TBM reported lower RPE, and were able to jump higher and sprint faster throughout the IEP, LBM:TBM had no effect on the degradation of lower extremity energy absorption with fatiguing exercise. Therefore, while overall performance may be dependent on body composition, body composition was not a factor in one's ability to maintain their performance or lower extremity biomechanics as fatigue ensued. Acknowledgements: Supported by NFL Charities

Changes In Time-To-peak Kinetics After Neuromuscular Fatigue

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Context: Neuromuscular fatigue is one likely factor for increased anterior cruciate ligament (ACL) injury rates at the end of halves or games. Researchers have found altered lower extremity kinetics post-fatigue that are prospectively linked to greater risk of ACL injury. However, no studies have examined how the rate of loading, measured via time-to-peak forces or moments, may be impacted by fatigue or the presence of interventions like verbal feedback. **Objective**: To quantify the effects of fatigue and verbal feedback on the rate of knee joint loading during an unanticipated sidestep cut. **Design**: Cross-sectional. **Setting**: Research laboratory. **Patients or Other Participants**: Fifty-nine club-sport athletes (31M, 28F; 19.8±1.6yrs, 176.7±9.2cm, 71.2±10.0kg) were randomly assigned to either receive verbal feedback (FB) or no feedback (NFB) post-fatigue. **Interventions**: The unanticipated sidestep cutting task involved a jump over a hurdle, triggering a randomized directional cue. The participant landed with the dominant foot on a force platform and cut 60° in the indicated direction. Participants then performed an intense, intermittent fatigue protocol involving multi-directional sprints and broad jumps. Testing procedures were repeated post-fatigue, but the FB group received instructions to "land softly, keep your knee over your toes, and make the movement 'smooth'". The NFB group received no instruction. **Main Outcome Measures**: A 7-camera motion capture system and force platform collected kinematics and kinetics. The length of the stance phase (initial contact:toe-off) was measured in milliseconds (ms). Time-to-peak (TTP) kinetics [vertical ground reaction force (VGRF), posterior ground reaction force (PGRF), knee extension moment (KEM), knee valgus moment (KVM), and anterior tibial shear force (ATSF)] were calculated pre- and post-fatigue from initial contact to the peak value during the first 40% of the stance phase. These kinetics were specifically chosen as they correlate with ACL strain *in-vivo*. Comparisons were made between groups and fatigue using mixed-model ANOVA's with Bonferroni post-hoc tests (a<0.05). **Results**: A significant fatigue x group interaction was observed for TTP VGRF ($F_{1,53}$=7.242, P=0.01). The NFB group decreased TTP VGRF post-fatigue (pre-fatigue: 52±21ms, post-fatigue: 41±15ms), whereas the FB group had no change (pre-fatigue: 43±14ms, post-fatigue: 41±11ms) (t=4.193, P<0.001). Significant fatigue main effects were found for TTP ATSF (pre-fatigue: 136±180ms, post-fatigue: 76±137ms, $F_{1,53}$=8.859, P=0.004) and total stance time (pre-fatigue: 995±281ms, post-fatigue: 1106±324ms, $F_{1,53}$=12.139, P<0.001). **Conclusions**: In general, fatigue appears to increase the rate of loading on the knee joint via shorter TTP VGRF and ATSF, despite a longer stance phase. However, feedback was effective at preserving TTP VGRF. Prior research using identical methods found fatigue increased the magnitude of ATSF and VGRF, which combined with lower TTP VGRF and ATSF would likely increase the strain on the ACL. Therefore, feedback may be one method to protect the ACL from injury under fatigued conditions.

Hip Abduction Torque Between Non-Specific Low Back Pain And Healthy Individuals With Repeated Exercise

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Context: Low back pain (LBP) is a prevalent condition that can lead to muscle weakness and adaptations. People with LBP have weaker core musculature potentially leading to instability. Weakness or poor endurance in the gluteus medius may be an easily treatable deficiency in patients with LBP. **Objective:** To compare isometric hip abduction torque of the gluteus medius muscle in healthy individuals to those with NSLBP following a repeated isometric side-lying hip abduction task. **Design:** Descriptive laboratory study **Setting:** Laboratory **Patients or Other Participants:** 24 subjects, 12 with a history of NSLBP (5M/7F, age=24±4, body mass index= 25.19±3.44, Oswestry low back pain scale=8.67±5.61, pain=1.06±0.88, Fear and Avoidance Belief questionnaire=18.00±8.07) and 12 healthy controls (3M/9F, age 22±3, body mass index=21.28±2.40, Oswestry low back pain scale= 0.67±1.23, pain=0±0, Fear and Avoidance Belief questionnaire 0±0). **Interventions:** Participants completed a total of five repeated isometric side-lying hip abduction trials of 30 seconds durations with 30 seconds rest between trials. Subjects were side-lying with the testing leg secured to an isokinetic dynamometer, and the back stabilized with foam rolls during testing. Testing of the opposite limb was conducted 20 minutes after completion of the first leg to reduce the effects of fatigue. **Main Outcome Measures:** Mean hip abduction torques of the dominant and non-dominant limb were recorded at 2 second intervals during the second to fourth seconds and the twenty-six to twenty-eighth seconds during each trial. Torque values were averaged between limbs, and normalized to body mass. A 2 x 2 ANOVA with repeated measures compared the average normalized hip abduction torque at the beginning of the first fatigue trial and the end of the last fatigue trial between groups. **Results:** There was no difference between groups ($F_{(1,23)}$=0.207, p=0.653) at the onset (NSLBP=1.52±0.42 Nm/kg, Healthy =1.62±0.30 Nm/kg) or following the repeated fatiguing exercise (NSLBP =1.10±0.42 Nm/kg, Healthy= 1.13±0.30 Nm/kg) for normalized hip abduction torque. There was a significant main effect of time within groups ($F_{(1,22)}$=71.120, p<0.001) following fatigue (Prefatigue = 1.57±0.36 Nm/kg, Postfatigue = 1.12±0.36 Nm/kg), but no group by time interaction ($F_{(1,22)}$=0.535, p=0.472). **Conclusions** Averaged normalized hip abduction torque decreases following fatigue, however no differences were observed between groups. An isometric side-lying hip abduction task is sensitive to changes in torque following prolonged exercise, however we are unable to discriminate between those with NSLBP likely to experience reoccurrences and those who do not have NSLBP.

Effects Of Hip Abductor Fatigue On Kinematics Of The Foot during Walking Gait

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Context: Multiple studies have found that control at the hip is essential for proper function throughout the distal lower extremity. Research has shown that hip function can affect function at the knee and ankle; but it is only assumed that there could be similar effects into the foot. Paucity in the literature currently exists regarding the effects hip fatigue or weakness has on foot mechanics during gait. **Objective**: The purpose of this study was to determine if there is a direct relationship between hip abductor fatigue and amount of subtalar pronation or supination during walking gait. Our hypothesis was that hip abductor fatigue will directly affect kinematics of the foot during walking gait on both the fatigued and non-fatigued legs. **Design**: A repeated measures design. **Setting**: Sports Medicine Research Laboratory. **Patients**: Seventeen healthy volunteers (10 men and 7 women) age: 22.17 ± 2.45 years, height: 174.0 ± 9.0 cm, weight: 170.59 ± 32.08 lbs were recruited to participate in the study. All participants were right foot dominant. **Interventions**: Participants completed five walking trials both pre and post completion of a hip abductor fatigue intervention on the dominant leg. Subjects wore a customized foot pressure system and 3D lower extremity reflective markers during the walking trials. The hip abductor fatigue protocol involved completing a side lying hip abduction movement to a pre-determined height with a 5lb weight attached to the lower leg of the dominant leg of all participants. Hip abduction movement was continued until failure. At that time, participants immediately performed the post

fatigue walking trial measures. **Main Outcome Measures**: Mean joint position during gait, maximal subtalar pronation and maximal subtalar supination in degrees; and mean center of pressure in millimeters during walking gait. A repeated measures ANOVA was utilized with alpha set a priori at d•0.05. **Results**: Significant differences were found for mean joint position (P=.048) and maximal supination (P=.019) between the fatigued and non-fatigued legs. Specifically, participants spent a longer time in a pronated position in the fatigued leg versus a supinated position in the non-fatigued leg. Further, the non-fatigued leg presented with a maximal supination angle of 12.6° compared to 4.9° for the fatigued leg. However, no statistically significant differences were found for maximal pronation (P=.074) or mean center of pressure (P=.186). **Conclusions**: Our results revealed that there is a relationship between hip abductor fatigue and foot kinematics. The significant differences found in our results suggest that compensatory actions occur between limbs which may potentially place athletes at a greater risk for lower extremity injury if hip abductor weakness or fatigue is present. Further research is needed to explore the effect hip abductor strengthening programs have on foot mechanics and the prevention of lower extremity injury.

The Effect Of Equalizing Task Demands According To Sex Differences In Lower Extremity Lean Mass During Landing

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Context: Females possess less relative lower extremity lean mass (LELM) and strength than males. Less LELM in females has been suggested as a factor influencing sex differences in lower extremity (LE) landing biomechanics, particularly greater relative energy absorption (EA) about the knee, which may lend towards their greater risk of ACL injury. However, sex comparisons in biomechanics may be biased as the majority of studies utilize experimental procedures in which males and females perform equivalent tasks (i.e. same drop height), thus requiring females to perform a task which is relatively more difficult. **Objective:** To determine the effect of equalizing task demands on relative LE joint energetics during a drop jump (DJ) according to differences in LELM between males and females. We expected sex differences in EA to decrease when task demands were equalized. **Design:** Descriptive Cohort. Setting: Controlled Laboratory. Patients or Other Participants: 35 female (1.67 ±0.1m, 65.3±6.6kg, 21.6±3.6yrs) and 35 male (1.78±0.1m, 74.7±8.9kg, 20.9±2.9yrs) athletes. Interventions: Participants were enrolled in male-female pairs, matched by similar body mass index. LELM was measured via dual-energy x-ray absorptiometry. LE biomechanics were assessed during a DJ from a standardized height ($Height_{STD}$) and after equalizing the task demands based on the difference in LELM within each pair ($Height_{EQU}$). **Main Outcome Measures:** LELM was normalized to body mass (%). Normalized EA ($J*N^{-1}*m^{-1}$) for the hip, knee, and ankle were calculated from the kinematic and kinetic data during the initial deceleration phase of the DJ landing and expressed relative to total EA (%). Separate ANOVAs compared males and females on joint EA before and after equalizing task demands. Results: LELM (Mean±SD) for females compared to males: 23.6±2.9 vs. 29.1±2.3%. During the $Height_{STD}$ condition (0.45±0.0m), males absorbed a greater proportion of total EA than females about the hip: 18.1±8.4% vs. 22.4±9.6% (p=0.05), with no differences at the knee: 60.5± 10.8% vs. 56.0±10.6% (p=0.08) or ankle: 21.3±9.3% vs. 21.6±7.0% (p=0.88). During the $Height_{EQU}$ condition (0.57±0.07m), males continued to absorb a greater proportion of energy about the hip: 18.1±8.4% vs. 23.1±9.5% (p=0.02), with no differences observed at the knee: 60.5±10.8% vs. 56.0±10.6% (p=0.08) or ankle: 21.3±9.3% vs. 20.8±7.0% (p=0.81). **Conclusions:** Equalizing task difficulty according to sex differences in LELM had no effect on the relative joint contributions to EA, which suggests that it is not just task demand driving the sex differences in biomechanics. These results may also point towards an inadequacy in the current methods for equalizing task demands according to LELM; there may be other factors that more accurately characterize relative task demands when comparing males and females. Future work should examine a more functional factor, such as strength, for equalizing task demands with the larger goal of making unbiased sex comparisons in future investigations. Supported by NATA Foundation.

Pubertal Maturation Effects On Lower Extremity Kinetics And Kinematics Of Adolescent Male Athletes During A Stop-Jump Task

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Context: There has been extensive research on the incidence of anterior cruciate ligament (ACL) injuries in the high school and collegiate population. However, ACL injuries have become increasingly common in the adolescent population, and there has been limited research investigating the cause. It has been suggested that changes experienced during pubertal maturation may affect lower extremity kinetics and kinematics during athletic maneuvers. **Objective:** To determine if pubertal maturation has an effect on lower extremity biomechanics of healthy adolescent male athletes during a stop-jump task. **Design:** Non-randomized cross-sectional study. **Setting:** Biomechanics laboratory. **Patients or Other Participants:** Thirty-three healthy male adolescent athletes between the ages of 9 and 14 (11.52±1.54 years, 1.53±0.14m, 44.22±11.37kg) volunteered to participate. Participants were placed into three maturational categories [pre-pubescent (PRE), early-pubescent (PUB), post-pubescent (POST)] based on the Pubertal Maturation Observational Scale that was completed by the participants' parent or legal guardian prior to participation. All participants were free of lower extremity injury during the time of the study. **Intervention:** Participants lower extremities were marked with 42 reflective markers prior to performing 5 trials each of an anticipated side-step cut and running stop-jump, followed by 5 trials each of an unanticipated side-step cut and an unanticipated stop-jump. Data were collected using eight high-speed Vicon motion analysis cameras and two Bertec force plates. Kinetic and kinematic data were measured and analyzed during the unanticipated stop-jump only. **Main Outcome Measures:** The independent variable was maturation stage(3), and the dependent variables were knee flexion (KF), knee abduction (KA), hip flexion (HF), hip abduction (HA), knee flexion moment (KFM), knee abduction moment (KAM), hip flexion moment (HFM), and hip abduction moment (HAM). All dependent variables were measured at initial contact (IC), peak knee flexion (PKF), peak vertical ground reaction force (PVGRF), and peak posterior ground reaction force (PPGRF). A one-way MANOVA was performed for each dependent variable across all time instances, with a Bonferroni adjustment set at *P*d".01. **Results:** For HA, PRE subjects demonstrated significantly greater angles than PUB subjects (IC: PRE -8.64±5.06, PUB -1.00±4.33, *P*=.002; PPGRF: PRE -8.34±5.20, PUB -0.40±4.80, *P*=.001; PVGRF: PRE -8.30±5.82, PUB -0.01±5.11, *P*=.002; PKF: PRE -7.00±6.75, PUB 0.74±5.30, *P*=.01). No significant differences (*P*>.01) were noted between maturation stages for all kinetic measures, KF, KA, and HF across all time instances. **Conclusions:** As a decrease in HA has been noted as a possible ACL injury risk factor, the differences demonstrated between pre-pubescent and post-pubescent males during the stop-jump may be a contributing factor to the rise in injury occurrence across maturation. Hip strengthening and other aspects of ACL prevention programs may decrease the risk of a non-contact ACL tear. More research is needed to further investigate the effects of maturation stage on lower extremity biomechanics in adolescent athletes.

Hip Abductor Induced Fatigue And Lower Extremity Joint Angles During Unilateral Drop Landings In Males And Females

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Context: Fatigue of abductor muscles of the hip may cause increased frontal plane knee motion leading to increased risk of knee valgus collapse. However, comparing landing mechanisms between males and females before and after lower extremity fatigue has not yet been investigated. **Objective**: The objective of this study was to assess gender differences in unilateral landing before and after hip abductor muscle fatigue. **Design**: Case controlled study. **Setting**: Laboratory **Patients or Other Participants**: Fifteen healthy male (age: 29.6±2.07 yrs; weight: 75.4±5.12 kg; height: 177.6±5.70 cm) and female (age: 22.6±3.29 yrs; weight: 57.9±5.68 kg; height: 163.4±4.64 cm) subjects were recruited for this study. **Intervention**: A continuous side lying hip abduction exercise was performed to induce fatigue until subjects were unable to touch target angle which was 35°. In order to confirm muscle fatigue, the gluteus medius muscle median frequency (MDF) was collected during exercise using a Delsys wireless EMG system (Delsys Inc, Boston, MA). **Main Outcome Measures**: Independent variables of this study were gender and fatigue status. Landing data were collected using a Vicon motion analysis system (Vicon Inc, LA, CA) during landing at 200 Hz. Since ACL injuries occur near 30° of knee flexion, all 3-D joint kinematics at the hip, knee, and ankle were analyzed in this specific angle. A gender by time mixed model two-way repeated measures of ANOVA were performed to analyze mean differences. Alpha level was set a priori at .05 for all analysis. **Results**: A significant main effect for fatigue was found in hip adduction/abduction at 30° knee flexion ($F_{1,27}$=6.39; P=0.00). Post hoc analysis showed that fatigue protocol resulted in decreased hip abduction angle at 30° of knee flexion (Pre: -8.06°±3.52°; Post: -6.19°±4.19°). A significant main effect for fatigue was also found in knee varus/valgus angles at 30° of knee flexion ($F_{1,27}$=30.83; P=0.00). Post hoc analysis showed that fatigue protocol increased knee valgus angles at 30° of knee flexion (Pre: -0.09°±4.23°; Post: -2.32°±4.58°). Other kinematic variables did not show significant main and interaction effect. **Conclusions**: Fatigue-induced changes in the lower extremity kinematics during unilateral landing may lead to lower extremity motions that are characteristic of ACL mechanisms of injury. However, there were no differences between gender which indicated that only fatigue do play an important role in controlling knee motion regardless of sex. Therefore, it may be necessary to enhance hip abductor muscle strength and resistance to fatigue in an effort to ensure safe maneuvering such as in sudden changes or unilateral landing which are common during sport events.

The Relationship Between Musculoskeletal Strength, Physiological Characteristics And Knee Kinesthesia Following Fatiguing Exercise

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Context: Fatiguing exercise may result in impaired functional joint stability and increased risk of musculoskeletal injury. While there are several musculoskeletal and physiological characteristics related to fatigue onset, their relationship with proprioceptive changes following fatigue has not been examined. **Objective:** To establish the relationship between musculoskeletal and physiological characteristics and changes in knee proprioception following fatigue. **Design:** Cross-sectional, correlational study design. **Setting:** Research laboratory. **Participants:** Twenty healthy, physically active females participated (age: 28.7±5.6 years, height: 165.6±4.3 cm, weight: 61.8±8.0 kg, BF: 23.3±5.4%). Subjects were free from lower extremity injury within the past year, surgery within the past 5 years, and had no history of ligamentous injury to the knee. **Interventions:** During Visit 1, subjects underwent threshold to detect passive motion familiarization (TTDPM, passive mode, 0.25°/s, 3 repetitions each for knee extension/flexion). In addition, isokinetic knee flexion/extension strength testing (60°/s, 5 repetitions each) and peak oxygen uptake (VO_2peak)/lactate threshold (LT) assessments were performed (treadmill protocol). During Visit 2, subjects completed TTDPM testing and isometric knee flexion/extension strength testing (5-

s, 3 repetitions each) immediately before and after a fatiguing exercise protocol designed to elicit upper/lower body, core, and general fatigue. Strength and TTDPM testing were performed on the dominant limb, defined as the limb used to maximally kick a ball. Wilcoxon signed rank tests determined TTDPM and isometric knee strength changes from pre- to post- fatigue. Spearman's rho correlation coefficients determined the relationship between isokinetic strength and physiological variables with pre- to post-fatigue changes in TTDPM and with pre-fatigue and post-fatigue TTDPM in extension and flexion (˜=0.05). **Main Outcome Measures:** Strength was reported as average peak torque normalized to body weight, VO_2peak as highest 15-s averaged O_2 uptake normalized to body weight, and LT as %VO_2peak. Mean absolute error from pre- to post-fatigue was calculated for TTDPM. **Results:** No significant differences were demonstrated in TTDPM from pre- to post-fatigue despite a significant decrease in isometric knee flexion strength ($P<0.01$) and flexion/extension ratio ($P<0.05$). No significant correlations were observed between strength or physiological variables and changes in TTDPM from pre- to post-fatigue. Isokinetic flexion/extension ratio was significantly negatively correlated with pre-fatigue TTDPM into extension ($r=-0.231$, $P<0.05$) and VO_2peak was significantly negatively correlated with pre-fatigue ($r=-0.500$, $P<0.01$) and post-fatigue ($r=-0.520$, $P<0.05$) TTDPM into extension. **Conclusions:** No significant relationships were demonstrated between musculoskeletal and physiological characteristics and changes in TTDPM following fatigue, which may be related to the high fitness level of these subjects. However, higher strength ratio and VO_2peak were associated with better proprioception pre- and post-fatigue. Future studies should consider different subject populations, other musculoskeletal strength characteristics, and different modalities of proprioception to determine the most important contributions to proprioceptive changes following fatigue. Supported by Freddie H. Fu, MD Graduate Research Award.

There Is A Relationship Between Knee And Hip Kinematics And The Reduction Of Vertical Ground Reaction Forces In Youth Soccer Athletes

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Context: It has been shown in adult populations that vertical ground reaction forces (VGRF) are absorbed primarily through altering knee kinematics and secondarily through changes in ankle angles in females and hip angles in males. As youth athletes demonstrate different landing biomechanics than that of adults it is prudent to assess their energy absorption strategies so that anterior cruciate ligament (ACL) injury prevention programs can address these changes in lower extremity kinematics to decrease forces at the knee. **Objective:** To identify relationships between decreased VGRF and knee and hip kinematic variables during a jump-landing task and determine how VGRF is being absorbed in youth soccer athletes. **Design:** Cross-sectional. **Setting:** Research laboratory. **Participants:** Twenty-nine healthy soccer athletes (females: n=12, age=10±1 years, height =141.68±4.51cm, mass= 33.28±4.40 kg; males: n=17, age=10±1 years, height=141.59±6.06cm, mass=32.59±3,73kg) volunteered to participate. **Interventions:** Two sets of three jump-landing trials were performed during a single testing session. Participants were provided with instructions regarding proper landing technique prior to each trial of the second set of landings. The task required participants to jump forward from a 30cm high box placed a distance of half their height away from a force plate, land with their dominant foot on the force plate, and immediately jump for maximal vertical

height. An optical three-dimensional motion analysis system and a force plate measured lower extremity kinematics and kinetics. **Main Outcome Measures:** Dependent variables included sagittal and frontal plane knee and hip angles at initial contact and peak values over the stance phase and peak VGRF which was normalized to body weight. Bivariate correlations were analyzed assessing the relationship between VGRF and all kinematic variables and were additionally analyzed by sex (d".05). **Results:** Analysis of all participants revealed significant moderate positive correlations between VGRF and hip flexion at intial contact (HFIC) ($r_{(27)}$=.404, p<.05) and between VGRF and peak hip flexion (HFP) ($r_{(27)}$=.442, p<.05). When analyzed by sex no significant correlations were found between VGRF and the kinematic variables for males, and females demonstrated a moderately strong significant negative correlation between VGRF and peak knee flexion ($r_{(10)}$=-0.578, p<.05). Correlations between VGRF and knee flexion at initial contact ($r_{(10)}$=.-0.573, p=.051) and peak knee valgus ($r_{(10)}$=.-0.206, p=.052) were approaching significance. **Conclusion:** In order to decrease VGRF youth soccer athletes alter hip flexion. This landing strategy is in contrast to their adult counterparts who favor changes in knee kinematics as a strategy in decreasing VGRF. The females in this study demonstrated landing in a more erect posture with increased hip extension followed by increases in peak knee flexion to absorb VGRF; this is concurrent with the literature on landing strategies in adult females. By understanding these force absorption strategies we can construct a more comprehensive ACL injury prevention program for these young athletes.

Frontal Plane Knee Laxity Is Predictive Of Measures Associated With Medial Knee Loading During Gait

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Context: Knee osteoarthritis (OA) onset and progression is related to gait biomechanics characteristic of medial knee loading. While frontal plane knee joint laxity has been associated with OA progression, it is unknown if frontal plane knee joint laxity is related to gait biomechanics commonly associated with medial joint loading and OA initiation. **Objective**: Determine if frontal plane knee laxity is related to frontal plane gait mechanics commonly associated with OA onset and progression after accounting for pertinent anatomy. **Design**: Cross-sectional. **Setting**: Controlled Laboratory. **Participants**: Forty healthy participants (20 females; 1.64±0.04m, 65.1±11.1kg, 21.7±3.1yrs; 20 males: 1.79±0.09m, 83.2 ±17.2kg, 25.1±3.6yrs) with no current orthopedic injury or history of surgery in left limb. **Interventions**: On a single day participants underwent goniometric assessment of lower limb alignment, frontal plane knee laxity testing using the Vermont Knee Laxity Device, and 10 trials of over ground walking at a self-selected pace. All testing was performed on the left limb. **Main Outcome Measures**: Tibiofemoral angle (TFA) represented the angle formed in the frontal plane by the anatomical axes of the femur and tibia. Varus and valgus knee laxity were determined at ±10Nm using the Vermont Knee Laxity Device. Lower extremity joint biomechanics during the stance phase of gait were normalized to 100 points and ensemble averaged over the 10 trials. Peak hip and knee adduction angles and peak external hip and knee adduction moments were extracted from the first 50% of stance phase. Separate linear regressions examined the extent to which absolute (varus) and relative (varus/valgus) knee laxity predicted the peak biomechanical measures, after accounting for TFA and sex. **Results**: After accounting for TFA (11.8±3.1°) and sex, lesser absolute (3.5±1.2°) and relative (0.77±.25) varus laxity predicted greater peak knee adduction angle (5.1±3.4°) (R^2"=17.5%, P"=0.014) and greater peak knee external adduction moment (0.039 ±0.010 $Nm*bw^{-1}*ht^{-1}$ $x10^{-2}$) (R^2"= 13.3%, P"=0.032). Laxity measures were not significantly predictive of peak hip adduction angle (5.8±4.2°) (R^2"=12.8%, P"=0.072) or peak external hip adduction moment (0.0570±0.011 $Nm*bw^{-1}*ht^{-1}$ $x10^{-2}$) (R^2"=13.7%, P"=0.070). **Conclusions**: After accounting for bony alignment and sex, lesser absolute and relative varus laxity predict knee biomechanics commonly associated with greater medial knee loading in healthy individuals. Mechanical restraints to frontal plane knee motion have the potential to affect chronic knee loading patterns that may predispose one to knee OA. Future work needs to further understand the predictive role of knee joint laxity in OA onset and progression.

Hip Abductor And External Rotator Strength Is Not Related To Medial Knee Displacement In Post-Pubescent Females

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Context: Anterior cruciate ligament (ACL) injuries are frequently seen during cutting and single leg landing movements. Excessive medial knee displacement (MKD) is theorized to be a risk factor for ACL injuries. Post-pubescent females demonstrate greater MKD and have a higher risk of ACL injury compared to their male counterparts. There is conflicting evidence regarding the role of hip strength in controlling MKD specifically in a high-risk population. **Objective**: To evaluate the relationship between hip abductor and hip external rotator strength with medial knee displacement (MKD) in post-pubescent high school female athletes. **Design**: Cross-sectional. **Setting**: Research Laboratory. **Patients or Other Participants**: Twenty-five post-pubescent high school female athletes (age= 16 ±1 years, mass= 58.6±7.4 kg, height= 166±8 cm) volunteered to participate in this study. **Interventions**: Maximal isometric hip abduction and external rotation strength were measured during two trials using a hand-held dynamometer. MKD was assessed during three trials of a standardized jump-landing task using three-dimensional motion analysis. The jump-landing task required participants to jump forward from a 30-cm high box a distance of half their height jump for maximum vertical height immediately upon landing. **Main Outcome Measures**: MKD was calculated as the displacement of the knee joint center between initial ground contact (ground reaction force>10N) and maximum knee flexion. The average value for MKD and strength were used for analyses. Separate Pearson correlation coefficients were calculated to evaluate the relationship between hip abductor strength and hip external rotator strength with MKD. A linear regression was performed to evaluate if hip abduction and/or hip external rotator strength significantly predicted MKD. **Results**: Neither hip abduction (r= -0.24, p=0.26) nor hip external rotation (r=-0.007, p=0.97) strength were significantly correlated with MKD or significantly predicted MKD (R^2=0.11, p=0.28) in post-pubescent females. **Conclusions**: These results suggest that increasing hip strength alone may be insufficient to control MKD and prevent ACL and other lower extremity injuries in this high risk population. Strength training of the hip musculature may still need to be addressed in prevention and rehabilitation programs, but should also be combined with teaching proper neuromuscular control through balance, plyometrics, and sport-specific exercises.

Hip External Rotation Strength Impacts Frontal Plane Hip Motion During Unanticipated Landing Activities In Collegiate Female Soccer Players

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Context: A number of lower extremity injuries have been linked to hip muscle weakness in both cross-sectional studies and theoretical papers. However, studies on the link between hip muscle strength measures and kinematic variables have been inconclusive or inconsistent. **Objective:** To examine the association between hip strength measures and landing kinematics during athletic-like tasks. **Design:** Cross-sectional correlation. **Setting:** Biomechanics laboratory **Participants:** Twenty-three healthy collegiate female soccer players (Age: 19.6±1.3 yrs, Height: 1.69±0.06 m, Mass: 63.3±6.6 kg) **Interventions:** A Lafayette manual muscle testing system™ was used with a standardized protocol to measure hip abduction and external rotation strengths. Participants performed three tasks while three-dimensional kinematic data of the lower extremity were collected. For each task, participants had to stride forward off of a platform, and land on a force plate with a single leg. Platform height and stride distance were normalized to the participant's vertical jump height and stride length, respectively. While in the air, participants were given one of three visual signals on a video screen, which would indicate one of three actions after landing; continue running forward (RUN), stop and balance on the landing leg (STOP), or cut to the side away from the landing leg (CUT). Visual 3D was used to process kinematic data during the landing phase, which was identified using vertical ground reaction force and corresponded to approximately the first 30% of total

ground contact time. Hip excursion was calculated as the difference between maximum and touchdown angle. Hip strength measures were normalized to body mass and segment lengths. Both normalized hip strength measures were simultaneously entered into three regression models with hip excursions as the outcome variables. **Main Outcome Measures:** Hip excursion (degrees) in each cardinal plane. Results: Hip External Rotation strength was significantly associated with hip excursion during landing in the Frontal plane during all three tasks (Stop R^2_{Adj}=0.243, B=0.768, t(20)=3.025, p=0.006; Cut R^2_{Adj}=0.476, B=0.889, t(20)=4.021, p=0.001; Run R^2_{Adj}=0.0.283, B=0.808, t(20)=3.267, p=0.004), but not in the sagittal or transverse planes. Hip Abduction strength was not associated significantly with any hip excursion measures. **Conclusions:** Regression coefficients demonstrate a positive association between hip External Rotation isometric strength and hip excursion in the frontal plane during unanticipated landing tasks. In the frontal plane, the stronger the hip external rotators were isometrically, the greater frontal plane hip excursion they demonstrated during unanticipated tasks. The association was greatest for the cutting task, which is a frontal plane activity when compared to the more sagittal plane tasks of stopping and running.

Understanding The Role Of Hip Muscle Activation In Controlling Lower Extremity Motion During Functional Tasks

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Context: Weakness of the hip musculature has been suggested to contribute to an increased risk of knee injuries due to decreased control of the hip. However, the relationship between hip strength and dynamic hip motion remains unclear, as many studies have not accounted for activation of the hip musculature during dynamic activities. **Objective**: To determine the role of hip torque and muscle activation in predicting hip kinematics during a drop-landing and single leg hop (SLH). **Design**: Descriptive laboratory study. **Setting**: Research laboratory. **Patients or Other Participants:** Seventy-eight (39 males, 39 females) healthy participants (22.1±3.5 yrs, 169.9±10.2 cm, 71.2±15.8 kg) volunteered for this study. **Interventions**: All measures were performed on the dominant stance limb. Hip abduction (standing, hip abducted 5°) and extension (supine, hip flexed 90°) torques were measured during maximal isometric voluntary contractions (MVIC) using an isokinetic dynamometer. Three-dimensional hip kinematics, gluteus medius (G_{med}) muscle activation and gluteus maximus (G_{max}) muscle activation were assessed during bilateral drop-landings (height=45cm) and SLH trials (hop distance=40% of height, minimal vertical height=5"). The highest peak torque over 3 trials for each strength measure, and the average hip angle at initial contact (IC), peak angle, total excursion, and average G_{med} and G_{max} pre-activation (250ms prior to IC) and post-activation (IC to maximum knee flexion) over 5 drop-landing and SLH trials were used for analyses. Separate step-wise linear regressions determined the extent to which hip muscle activation and hip torque predicted hip kinematics during a drop-landing and SLH. **Main Outcome Measures:** Hip torque was measured in Newton-meters and normalized to body mass ($Nm \cdot kg^{-1}$). Frontal and transverse plane hip angles (°) at IC, peak angle during the landing (IC to maximum knee flexion), and joint excursion (peak minus IC angle) were extracted. The average root mean square (RMS) amplitude of the G_{med} and G_{max} during the drop-landing and SLH were normalized to the peak RMS value during MVIC for each muscle (%MVIC). **Results:** In females, less G_{med} pre-activation (0.32±0.15% MVIC) predicted less hip internal rotation at IC (0.53±6.07°) during a drop-landing (R^2=0.145, *P*=0.017) and less peak hip internal rotation (-4.42±7.79°) during a SLH (R^2=0.115, *P*=0.038). In males, less G_{med} post-activation (0.932±0.658%MVIC) predicted less peak hip internal rotation (-10.79±7.45°) during a drop-landing (R^2=0.210, *P*=0.005) while less hip extension torque (3.52±0.80 $Nm \cdot kg^{-1}$) predicted greater hip internal rotation excursion (-3.13±3.18°) during a SLH (R^2=0.248, *P*=0.016). Hip muscle activation and torques were not significant predictors of other hip kinematics (*P*>0.05). **Conclusions:** While hip torque was associated with hip internal rotation excursion in males, activation of the G_{med} was a consistent predictor of hip kinematics during dynamic tasks. Future studies should account for hip muscle activation when investigating neuromuscular control of lower extremity motion and risk factors for knee injuries.

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Knee Joint Stiffness Differs Among Athletes With Varying Conditioning Histories

Oates DC, Needle AR, Kaminski TW, Swanik CB: University of Delaware, Newark, DE. and Campbell University, Buies Creek, NC

Context: Maintaining functional joint performance and stability is dependent on the ability to optimally regulate stiffness while preparing and reacting to the onset of loads. However, previous research is unclear with respect to the types of training or conditioning histories that may promote different optimal joint stiffness levels. Training with low repetitions and high weight (power), as well as training with high repetitions and low weight (endurance) are both related to several neurophysiological adaptations; however, it is unclear how these conditioning histories affect joint stiffness. **Objective:** To assess the effect of conditioning history on knee joint stiffness under various reactive conditions. **Design:** Post-test only. **Setting:** Biomechanics laboratory. **Patients or Other Participants:** Forty-two male collegiate athletes (20.1±1.3yrs, 73.0±12.0kg, 176.4±6.2cm) with no history of knee injury volunteered for this study. Subjects included endurance athletes (END, 15 cross-country runners), power-trained athletes (PWR, 12 sprinters), and 15 recreational athletes (CON). **Interventions:** Subjects were tested on a customized stiffness assessment device that generated a rapid 40° flexion perturbation to the knee (30° to 70° flexion arc). Perturbations were randomly applied in 5 different conditions: passively (no muscle contraction, PS), actively contracted (85% effort, AS), relaxed with subjects reactively stiffening the joint (PRS), pre-contracted (85% effort) with subjects reactively stiffening the joint (ARS), and pre-contracted (85% effort) with subjects asked to

reactively deactivate and relax (DS). **Main Outcome Measures:** Normalized knee joint stiffness (˜torque/˜position, Nm/°/kg) was calculated at the short-range (0-4°), and for the total perturbation (0-40°). Differences were assessed using a 3-way analysis of variance to compare across groups (3-levels), conditions (5-levels), and stiffness ranges (2-levels). **Results:** A significant 3-way interaction effect was observed (F8,156=2.52,p=0.013). Pairwise comparisons revealed short-range stiffness was greater in END (0.0569±0.0028 Nm/°/kg) than CON (0.0474±0.0028 Nm/°/kg, p=0.021) under the passive condition. Total stiffness was higher in PWR (0.0020 Nm/°/kg ±0.003) than END (0.0009±0.0002 Nm/°/kg, p=0.016) in the passive condition. Additionally, for ARS, END (0.0507±0.004 Nm/°/kg) had higher total stiffness than CON (0.0289±0.004 Nm/°/kg, p=0.001) or PWR (0.0372±0.005 Nm/°/kg, p=0.044) groups. **Conclusions:** Our results indicate conditioning history changes stiffness regulation strategies in response to knee perturbations. Higher joint stiffness was observed in power-trained athletes under the passive condition, indicating a potential alteration in the fusimotor reflexes while at rest. Furthermore, our results found that endurance-trained athletes had higher knee joint stiffness during the reactive trials with a larger range of motion. As this perturbation condition is more representative of a functional task, it suggests that training with low-load and high repetitions may be more beneficial for achieving greater joint stiffness when necessary.

Force Sense Does Not Differ Between Power And Endurance Trained Collegiate Athletes

An YW, Oates DC, Needle AR, Kaminski TW, Swanik CB: University of Delaware, Newark, DE, and Campbell University, Buies Creek, NC

Context: Recent studies have linked deficits in the early detection of joint loading to recurrent episodes of instability. Force sense (FS) is a perception influenced by adaptations to Golgi Tendon Organs (GTO) and muscle spindles, which play an important role in regulating joint stiffness and responding to injurious loads. Enhancing force sense through specific types of conditioning programs may be desirable during prevention and rehabilitation, but it is unclear whether power or endurance training would convey any advantages. **Objective:** To determine if conditioning history influences FS perception. **Design:** Case-control study. **Setting:** Biomechanics laboratory. **Patients or Other Participants:** Forty-two male athletes (20.1±1.3yrs, 73.0±12.0kg, 176.4±6.2cm) with no history of knee injury volunteered for this study. Subjects included endurance athletes (END, 15 cross-country runners), power-trained athletes (PWR, 12 sprinters), and 15 recreational athletes (CON). **Interventions:** Subjects were tested for quadriceps and hamstrings FS at 30% of their maximum voluntary isometric contraction on a custom-built assessment device. Subjects were allowed practice with visual feedback of force prior to the first trial but no feedback was provided between trials. Subjects were instructed to exert their target torque and depress a hand-held switch. A period of 500ms from depression of the switch was used to determine matched force. Order of testing was randomized. **Main Outcome Measures:** The independent variables were group (END, PWR, CON) and muscle (hamstrings and quadriceps). Dependent variables included relative error (RE, %), coefficient of variation over the 500ms match (CV, %), and time-to-matched torque (sec). Separate repeated-measures analysis of variance was used to determine differences between muscles (2 levels) and groups (3 levels). **Results:** The main effect for conditioning history (group) was not significant for RE ($F2,39$=0.220, p=0.803), CV ($F2,39$=1.068, p=0.353), or time-to-matched torque ($F2,39$=0.674, p=0.515). Mean ± SDs of RE for the hamstrings were END= 26.37± 18.17%, PWR= 33.44± 18.33%, CON= 33.74±20.53%, and the quadriceps were END=37.62 ±30.29%, PWR=33.08±16.97%, CON=25.2±18.34%. Mean ± SDs of time-to-matched torque for the hamstrings were END=2.72±1.21 sec, PWR=2.45± .88 sec, CON=2.4±1.02 sec, and for the quadriceps were END=3.14±1.18 sec, PWR= 2.99±1.22 sec, CON=2.54±1.29 sec, respectively. The main effect for muscle was not significant for RE ($F1,39$=0.030, p=0.864) or CV ($F1,39$=0.162, p=0.690). Mean ± SDs of RE for the hamstrings and quadriceps were 31.18±2.96% and 31.97±3.58%, respectively. However, the main effect for muscle for time-to-matched torque was significant ($F1,39$=11.12, p=0.002). Time-to-matched torque for the hamstrings (2.52±0.17 sec) was faster than quadriceps (2.89±0.19 sec). **Conclusions:** Our findings revealed that conditioning history does not affect FS and that the time-to-matched torque was faster for the hamstrings compared to the quadriceps in healthy subjects. FS does not appear sensitive to differences in physical conditioning among healthy subjects; therefore future studies may explore whether FS deficits existing in injured populations may benefit from conditioning programs.

Hip Abductor Peak Torque As A Predictor Of Rapid Force Production And Strength Endurance

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Context: Lower extremity muscular strength deficits may increase an athlete's susceptibility to injury. Many have proposed the inclusion of maximum strength evaluations into pre-participation screening exams. However, strength consists of three parameters (maximum strength, rapid force production and strength endurance) and there is minimal evidence indicating maximum strength as a predictor of these other qualities. **Objective:** To determine the extent to which maximum strength predicts other qualities of strength. **Design:** Within-subjects correlational study. **Setting:** Research Laboratory. **Patients and Other Participants:** Thirty-three recreationally active females (20.94±2.86 yrs, 168.75±7.58 cm, 67.75±13.72 kg). **Interventions:** The investigators collected isometric maximum strength (i.e. peak torque) and rate of torque development data simultaneously from the hip abductors in a standing position using a load cell and data acquisition system at 1 kHz. To calculate the rate of torque development from 0-50 and 0-200 milliseconds, the investigators used the initial 200 millisecond after the contraction. Isometric rate of torque development test consisted of three 5-second trials with a 60-second rest between trials. Following a 10-minute rest, the participant underwent isometric strength endurance testing, which consisted of two 30-second isometric contractions separated by a two-minute rest. **Main Outcome Measures:** Hip abduction peak torque (Nm), rate of torque development (Nms-1) from 0-50 and 0-200 milliseconds and strength endurance were calculated as a percent fatigue using a fatigue index (FI): FI = [1 – (area under the torque-time curve 0-30 seconds /maximum force 0-5 seconds x 30)] x 100. To address the research question of the present study the investigators used three simple linear regression analyses. **Results:** The *M*+*SD* for peak torque and strength endurance was 112.60±31.66 Nm and 29.99±7.34 percent, respectively. The *M*+*SD* for rate of torque development at 0-50 and 0-200 milliseconds was 1838.73±588.84 Nm"s-1 and 455.78±144.60 Nm"s-1, respectively. Peak torque was a significant predictor of rate of torque development from 0-50 milliseconds [$F(1, 31) = 433.19$, $p < .001$, $R2$ adjusted = .93] and from 0-200 milliseconds, [$F(1, 31) = 233.09$, $p < .001$, $R2$ adjusted = .88]. Peak torque was not a significant predictor of strength endurance, [$F(1, 31) = 2.50$, $p = .117$, $R2$ adjusted = .05]. **Conclusions:** Although, isometric abductor peak torque is a predictor of rate of torque development from 0-50 and 0-200 milliseconds these results suggest peak torque does not predict an individual's ability to sustain (i.e. endurance) force isometrically at the abductors.

Lower Extremity Muscle Activity While Wear A Functional Knee Brace

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Context: The use of functional knee braces among athletes to prevent injury is common. However, the application of knee braces can alter the electromyographic amplitude and timing characteristics of thigh musculature. There is little research that evaluates the effects of a functional knee brace on trunk, hip and crural musculature. **Objective:** To compare lower extremity electromyographic muscle activity during a drop landing task with and without functional knee braces. **Design:** Randomized, controlled cross over design. **Setting:** Laboratory. **Patients or Other Participants:** Twenty-four young healthy adults (height= 172±9cm, mass= 69.65±1.4kg, age= 21.63± 4.4yrs sex=M:8 F:16). **Interventions:** Each participant performed 10 drop landing tasks in both the braced and non-braced conditions, in random order. The brace was placed on the dominant leg (leg used when kicking). The drop landing task consisted of jumping off a 30.5cm box landing on both feet and immediately performing a maximum vertical jump. **Main Outcome Measures:** Surface EMG was collected from the lumbar paraspinals, gluteus medius, vastus lateralis, biceps femoris, medial gastrocnemius, peroneus brevis, and tibialis anterior. Normalized surface EMG mean amplitude (50ms immediately prior to contact (pre-contact 1), 50ms immediately following initial contact (post-contact 1), 50 ms prior to vertical jump (toe-off), 50ms immediately prior to the second initial contact (pre-contact 2) and 50ms following the second contact (post-contact 2)), time to activation relative to first contact, and percent

activation across total foot contact time. Muscle activation threshold was reached if the amplitude exceeded 10 standard-deviations above that of quiet standing. Percent of activation was calculated as the total time across the stride cycle that the amplitude exceeded activation threshold. Non-normally distributed data were compared between bracing conditions using Wilcoxon signed-ranked test for each dependent variables. Alpha level was d"0.05. **Results:** The pre-contact 1 amplitude of the tibialis anterior was significantly lower in the brace condition when compared to the non-braced condition (31.36±29.57 vs. 32.56±34.95, p=0.007). The medial gastrocnemius was activated significantly earlier relative to initial contact in the braced condition when compared to the non-braced condition (-0.109±0.102 vs. -0.073±0.13ms, p=0.05). The medial gastrocnemius and gluteus medius were activated for a significantly longer percentage across total foot contact time in the braced condition when compared to the non-braced condition (MG: 57.3±24.8 vs. 52.7±23.6%, p=0.03; GM: 48.0±32.4 vs. 40.8±30.2, p=0.03). **Conclusions:** A functional knee brace alters the activation of the tibialis anterior and the timing characteristics of the medial gastrocnemius and gluteus medius in healthy young adults. It is not clear whether these changes would influence performance or injury risk.

Knee Stiffness Regulation After The Startle Response And Hormonal Changes

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Context: Growing evidence suggests the nervous system has a significant role in the high rate of non-contact anterior cruciate ligament injuries. Females are the most susceptible, but evidence for a hormonal role is conflicting. The startle reflex is universal across animals and stiffens limb muscles after sudden, unanticipated events. No studies have investigated how hormonal changes during the menstrual cycle may interact within the nervous system to alter the startle response and knee stiffness regulation among males and females. **Objective:** To assess if reactive knee joint stiffening strategies are affected differently in males and females during an acoustic startle. **Design:** Post-test only with repeated measures. **Setting:** University laboratory **Patients or Other Participants:** 16 males (21.3±2.0 yrs, 82.8±15.8 kg, 179.5±6.9 cm) and 16 females (20.9±2.0 yrs, 61.8±7.6 kg, 164.4±6.8 cm) with no previous knee injury participated in this study. All females were tested at 2 points in the menstrual cycle to form 3 groups: Males (M), Female-Follicular (FF), and Female-Ovulation (FO). **Interventions:** Subjects were seated on a custom stiffness device that generated a rapid 40° flexion perturbation to the knee (30° to 70° flexion arc). Subjects remained relaxed prior to the perturbation, and were instructed to react with maximal extension force as quickly as possible when the perturbation was sensed. A total of 6 trials were performed, with an acoustic startle (50ms, 1000Hz, 100dB) applied 100ms prior to the perturbation on 3 randomly selected trials. **Main Outcome Measures:** Normalized knee stiffness (˜torque/˜position, Nm/°/kg) was calculated at the short-range (0-4°) and for the total perturbation (0-40°). The average of the control (CON) and startle trial (ST) were used for analysis. Repeated-measures analyses of variance comparing gender (M, FF, FO) and startle condition (CON, ST) were used for analysis at both short-range and total range. **Results:** The startle significantly increased short-range stiffness ($F=4.24$, $p=0.04$), and decreased total ($F=11.25$, $p<0.001$) stiffness. Pairwise comparisons revealed that at short-range, ST displayed a significantly greater stiffness of 0.047±0.002Nm/°/kg, ($p=0.003$) compared to the CON (0.043±0.003Nm/°/kg). However, for total stiffness, the startle response caused significantly less total stiffness (0.028±0.002Nm/°/kg) than the CON (0.037±0.002Nm/°/kg, $p=0.004$) condition. No significant gender or menstrual cycle phase differences were observed for stiffness values. **Conclusions:** This is the first study to indicate that the startle response can significantly disrupt the normal knee stiffness regulation strategies that are required to maintain joint stability, and this effect may occur equally in males and females. Gender and menstrual cycle phase do not appear to affect knee stiffness or negatively interact with the startle response. Further studies should explore the potential role of startle responses in accidents and unintentional non-contact injuries.

Muscle Activity Of The Vastus Medialis And Vastus Medialis Oblique Are Differentially Modulated By The Menstrual Cycle

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Context: Patellofemoral pain incidence is more than twice as high in females than in males. This may be due to differences in the activation of the muscles that stabilize the patella. In vitro and in vivo evidence suggest that sex hormones can modulate motor neuron activity. **Objective**: To examine the differences in motor unit (MU) recruitment patterns of the vastus medialis (VM) and the vastus medialis oblique (VMO) muscles across the menstrual cycle and in males. We hypothesized that MU recruitment would be delayed and initial firing rate would be lower in the VMO compared to the VM in the ovulatory and luteal phases of the menstrual cycle due to elevated sex hormones. **Design**: The data is considered cross-sectional since different MUs were presumably sampled on each testing date. **Setting**: Controlled laboratory. **Patients or Other Participants**: 11 males (24.6±5.1 yr) and 7 eumenorrheic females (24.9±4.3 yr) participated. From these participants, 510 MUs were analyzed. **Interventions**: Using basal body temperature mapping, 5 menstrual phases were determined for data collection. Males attended only one session. All sessions consisted of an isometric ramp knee extension up to 30% maximal force. Before the contraction, intramuscular electrodes were inserted into the VMO and VM. Individual MUs were identified based upon shape and discharge timing. MU recruitment threshold was defined as the force at which 4 consecutive discharges occurred. The initial firing rate was the average of these intervals, converted to hertz. ANCOVA analysis was performed with VM/VMO comparisons at each menstrual phase and males to determine if initial firing rate was different after controlling for recruitment threshold. A Wilcoxon rank-sum test was used to determine if the VM and VMO had different recruitment threshold distributions. **Main Outcome Measures**: The dependent variables were initial firing rate, which is continuous, and recruitment threshold, which is a bounded measure with a right-skewed distribution. **Results**: Similar VM and VMO recruitment threshold distributions were observed in the early follicular phase ($p=0.728$; VMO median=8.7%; VM median =8.7%) and there were no differences observed in the other phases or males ($p>0.05$). The initial firing rate was significantly lower in the VMO than in the VM at the ovulatory ($p=0.007$; VMO= 8.0±0.4 Hz; VM= 9.1±0.4 Hz) and mid luteal ($p=0.007$; VMO= 7.9±0.4 Hz; VM= 9.1±0.4 Hz) phases. No differences between the muscles occurred at the other phases or in males ($p>0.05$). **Conclusions**: The initial MU firing rate of the VMO is lower than in the VM at the ovulatory and mid luteal phases. The lower activation of the VMO compared to VM due to hormonal oscillations may increase lateral glide of the patella and predispose females to a higher incidence of patellofemoral pain compared to males.

Sex, Hormones, And Use Of Contraceptives On Neuromuscular Function

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Context: Fluctuating hormones of the menstrual cycle may influence the rate of non-contact anterior cruciate ligament (ACL) injuries, with increased risk prior to ovulation when estrogen levels peak. Females have shown increased strength and altered neuromuscular activation prior to ovulation. These findings have not been replicated in females using oral contraceptives, which prevent the menstrual cycle. **Objective**: To determine the effect of sex, hormones, and contraceptive use on knee neuromuscular function at three points coinciding with the menstrual cycle. **Design**: Decroptive cohort. **Settings**: Controlled laboratory. **Participants**: Thirty healthy physically active college-age students volunteered (10 males [M], height=182.40 ± 8.47cm, mass=76.41 ± 11.33kg; 10 female OC [FOC], height=169.33 ± 7.47cm, mass=71.34 ± 17.83 kg; 10 female non-OC [FNOC], height= 72.80 ± 5.12cm, mass=68.78 ± 10.57cm). **Interventions**: Participants completed three testing sessions (1/follicular, 2/ovulatory, 3/luteal). FOC testing sessions were scheduled based on contraceptive pill day, FNOC were scheduled around self-report and a positive ovulation test. A standardized testing protocol was followed. Participants completed 3 drop jumps off a 46-cm box, landing on a force plate. Data from area electromyography (EMG [% maximum voluntary isometric contraction]) of the rectus femoris

(RF) and biceps femoris (BF) were collected 250ms pre- and post-land. Force plate data were used to calculate vertical leg stiffness (VLS) during the eccentric phase of landing and normalized with a liner regression-based correlation using body weight. **Main Outcome Measures:** Neuromuscular activation (RF, BF) by group (M, FOC, FNOC), testing session (1/follicular, 2/ovulatory, 3/luteal), and time period (pre, post); and VLS by group (M, FOC, FNOC) and testing session (1/follicular, 2/ovulatory, 3/luteal). A multiple analysis of variance was used to analyze EMG data, while an analysis of variance was used to analyze VLS (*p*d".05). **Results**: Post-land, EMG area of RF (pre=19.71 ± 1.46%, post=46.23 ± 25.36%) and BF (pre=9.40 ± 6.18%, post = 19.69 ± 14.71%) were significantly greater than pre-land across groups and testing sessions (F=3.71, $p<.001$). No other significant interactions or main effects for EMG data were observed. A significant difference existed between groups with respect to VLS (F=4.66, $p=.012$). Males (88.15 ± 51.86kN/m) and FOC (81.09 ± 55.53kN/m) had significantly greater VLS than FNOC (52.66 ± 26.53). **Conclusion**: Neuromuscular activation was not affected by sex, hormones, or contraceptive use. Lower extremity stiffness was affected by sex and contraceptive use. Males and FOC experienced greater levels of stiffness than the FNOC group. Higher levels of stiffness are theorized to be more protective of the ACL. There was no evidence that variation within the menstrual cycle affected neuromuscular function. Future research should explore the relationship between neuromuscular activation, stiffness, and hormones in relation to ACL injury. A smaller time frame is needed to examine EMG activation as it relates to stiffness.

Development Of A Patient-AT Trust Instrument Using A Focus Group

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Context: Patient care has had a paradigm shift from the disease-centric to the patient-centered focus, making the patient the centered of the health care plan. This change emphasizes that patients and caregivers communicate effectively so patients can actively participate in their healthcare decision process. Patient trust is an important factor in this communication. It has been linked to increased adherence and ultimately better treatment outcomes. Despite the positive benefits the definition and factors of trust have varied across healthcare settings with little attention to the application in athletic training. The long-term purpose of this multi-phased project is to develop an instrument to quantify trust in AT through a mixed methods approach and psychometric testing standards. **Objective:** The purpose of this study (phase 1) was to understand key components of trust in the athletic training (AT) setting through qualitative inquiry. **Design:** A qualitative focus group was completed using grounded theory techniques. **Setting:** A quiet classroom. **Participants:** A typical, stratified purposeful sample of six college-aged Division I student-athletes (5 females; 1 male; 20±1.6 yrs) from a variety of sports (field hockey, wrestling, and volleyball) participated in a focus group. **Data Collection and Analysis**: Focus group questions were targeted to better understand the definition and factors of trust related to AT. We used initial data collected in the AT setting from a modified psychotherapy trust scale to provide participants with background information and a concept of trust to help facilitate discussion of ideas. We were able to provide relative item difficulty of initial trust items that were calibrated using Rasch Rating Scale Model, which places items and people on a common metric. Trustworthiness of the data was ensured using an external auditor, member checks, and methods triangulation. **Results:** The focus group revealed seven themes: fidelity (decision making with the patient's best interest in mind), education, competence, confidentiality, reliability, time/availability, and communication. Each theme was further classified into one of two categories: personal attributes or personalization. Personal attributes were personal characteristics of the athletic trainer while personalization was making the treatment approach individualized with the patient at the center of the health care. Personal attributes were: time/availability, communication, confidence, and knowledge while personalization themes were: fidelity, education, and confidentiality. **Conclusion:** Results from the two main categories provide a framework for trust in the AT setting. The themes from this qualitative study provide a blueprint for item development to ensure each theme is adequately represented. This will ultimately lead to the development of a psychometrically sound AT trust instrument.

Reliability Of Bony Anatomic Landmark Assessment In The Lumbopelvic Region

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Context: The ability to palpate bony landmarks within the lumbopelvic region is considered to be a basic skill needed for application of treatment techniques and assessment of patient progress. Assessment of athletic trainers(ATCs) accuracy of this measurement has not been examined. **Objective:** To examine intra- and inter-tester reliability of four ATCs for identification of the L4 spinous process and the right and left posterior superior iliac spine(PSIS) compared to expert raters. **Design:** Cross-sectional reliability. **Setting:** Laboratory **Participants:** Sixteen physically active adults (age= 22.56±2.67yrs, ht= 172.0± 9.38cm, mass= 67.39± 9.73kg, BMI= 22.8± 1.97) volunteered to participate. Four novice ATCs (certified<1yr) served as the testers of interest. **Intervention:** The subjects were placed in a prone position and two expert ATCs (certified>12yrs) agreed upon each bony landmark and transferred the expert markings to contact paper. The contact paper and skin of the participant were aligned via permanent markings, which were also used to align the tester contact paper when transferring markings. Each tester palpated the landmarks twice within the same test session by utilizing invisible pens and ultraviolet light. Testers rotated between subjects after one marking trial. Testers transferred their own markings and removed the markings with alcohol wipes, prior to testing the next subject. Expert marks were transposed over the tester marks via transparency on which the contact

paper was attached. **Main Outcome Measurements:** The independent variables were tester(T1,T2,T3,T4) and time(Trial 1,Trial 2) and the dependent variables included distance from the expert marking in millimeters(mm) for L4 and PSIS palpations, and agreement as to whether marks landed within or outside of a designated area for the L4 spinous process. The predetermined area included a rectangular box transposed over the expert markings as determined by previous research. Intraclass correlation coefficients ($ICC_{2,1}$) and standard error of measurement(SEM) were calculated to determine the intra- and inter-tester reliability for all objective assessments. Percent agreement was also calculated for each tester (between expert and novice) for L4 markings. **Results:** Intra-tester $ICC_{2,1}$'s for L4 ranged from $ICC_{2,1}$=-0.14(SEM=2.49mm) to $ICC_{2,1}$=0.83 (SEM=4.62mm). Inter-tester $ICC_{2,1}$'s for L4 were $ICC_{2,1}$=0.16 (SEM =7.02mm) for Trial 1 and $ICC_{2,1}$=0.26(SEM=6.1mm) for Trial 2. Percent agreement between expert and testers ranged from 13-56% for L4. Intra-tester $ICC_{2,1}$'s for right PSIS ranged from $ICC_{2,1}$=-0.15(SEM= 4.03mm) to $ICC_{2,1}$=0.77 (SEM= 3.21mm) and left PSIS ranged from $ICC_{2,1}$=-0.17(SEM=6.44mm) to $ICC_{2,1}$=0.74(SEM=3.81mm). Inter-tester $ICC_{2,1}$'s for right PSIS were $ICC_{2,1}$=0.17(SEM=4.36mm) for Trial 1 and $ICC_{2,1}$=-0.001(SEM=4.86) for Trial 2. Inter-tester $ICC_{2,1}$'s for left PSIS were $ICC_{2,1}$=0.15 (SEM= 4.76mm) for Trial 1 and $ICC_{2,1}$=-0.05(SEM=5.57mm) for Trial 2. **Conclusion:** Our results indicate poor to moderate intra-tester reliability for palpation of bony landmarks in the lumbopelvic region for newly credentialed ATCs, as well as poor inter-tester reliability and agreement. Competency in palpation skills throughout professional education should be confirmed in order to ensure proper treatment application and pathology assessment within clinical practice.

Reliability And Validity Of A Standing Hip Isometric Endurance Test For Generating Muscle Fatigue

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Context: Muscle fatigue is a common consideration when evaluating and rehabilitating athletic injuries. Current assessments of hip muscle fatigue are performed in seated and/or lying positions. Research has not determined if a prolonged isometric test in a standing position is a reliable and valid technique for generating muscular fatigue of the hip. **Objective:** To determine the reliability and validity of a standing hip isometric endurance test to generate muscle fatigue. **Design:** Cross-sectional design. **Setting:** Laboratory. **Patients or Other Participants:** Twenty healthy recreationally active individuals(10 male, 10 female; age=25.2±3.3years; height= 175.1 ±11.6cm;mass=70.6±15.4kg) participated. Participants were excluded if they scored above 9.33 on the Disablement in the Physically Active Scale, had a lower extremity injury within 4 months, or did not partake in physical activity for at least 30 minutes, 3 times per week. **Intervention:** Participants completed two sessions of testing within the same day. The second session began approximately 30 minutes after the firstsession. Electromyographic (EMG) surface electrodes were placed on the rectus femoris(RF), biceps femoris(BF), gluteus maximus (GMax), gluteus medius (GMed) and adductor longus(ADD) of the dominant limb. Endurance testing was conducted through a single 60-second hip flexion, extension, adduction, and abduction Maximum Voluntary Isometric Contraction on an isokinetic dynamometer in a standing position.

Two minutes of rest was provided between trials and the order of hip action was counterbalanced. **Main Outcome Measures:** Median frequency(MF), interpreted as the rate of conduction of muscle fibers, was used to quantify fatigue. MF was examined from the EMG signal of the primary muscle of each hip action (Flexion=RF, Extension=BF and GMax, Adduction=ADD, Abduction =GMed) for the first and last 15s of each trial through power spectral analysis (Hz). Intra-session reliability was assessed for each action using intraclass correlation coefficients (ICC[3,1]). Face validity of the endurance test was examined through paired t-tests for each action between the two time intervals(0-15s,46-60s) of the data collected in the second session. Decreases in MF represented fatigue of fast twitch muscle fibers, leaving slow twitch fibers to sustain activity. Descriptive statistics were calculated as mean±standard error. Alpha level was set at pd"0.05. **Results:** The ICC[3,1] values for intra-session reliability were good-to-excellent for both time intervals(0-15s,46-60s) of each action (Flexion=0.95,0.84; Ex-tension$_{BF}$ =0.92,0.95; Ex-tension$_{GMax}$ = 0.64,0.84; Adduction =0.79,0.90; Abduction= 0.91,0.62). Significant decreases in MF were detected over time for Flexion(0-15sec= 83.66 ±1.72Hz;46-60s=74.22 ±3.74Hz; p<0.001), Extension$_{BF}$(0-15s= 83.75±3.74Hz;46-60s= 74.37±3.82Hz;p<0.001), Extension$_{GMax}$(0-15s= 57.72 ±4.10 Hz;46-60s= 48.29± 2.26Hz; p=0.001), and Adduction(0-15s= 61.03 ±1.40 Hz;46-60s= 49.97± 1.95Hz; p<0.001). Although MF decreased during Abduction, statistical significance was not reached(0-15s =75.36 ±3.90Hz;46-60s= 69.59 ±3.03Hz; p=0.132). **Conclusion:** The MF associated with the 0-15s and 46-60s time intervals of the 60-second standing hip isometric endurance test displayed suitable intra-session reliability for all hip actions. The decrease in MF over time indicates this protocol generates fatigue for all hip actions, except abduction. Therefore, the endurance test used in this study is a reliable and valid technique to generate muscular fatigue for hip flexion, extension, and adduction.

Reliable Change Index Of Scapular Upward Rotation

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Context: Recently, the importance of scapular upward rotation in relation to chronic shoulder pathology has been highlighted. However, a reliable change index (RCI) of scapular upward rotation has not been established to help identify true difference as opposed to the result of random variation in measurements. The establishment of RCIs will assist with the interpretation of both statistically and clinically significant changes in scapular upward rotation measurements. Jacobson proposed that change should reflect more than fluctuations of a potentially imprecise measuring instrument. **Objective:** To determine the RCI for scapular upward rotation at four commonly assessed shoulder angles. **Design:** Prospective test-retest. **Setting:** Biomechanics research laboratory. **Patients or Other Participants:** Twenty-six males with no history of shoulder injury participated in this study: (age: 22.2±2.6 years, height: 1.77±0.07 m, weight:76.9±10.9 kg). **Interventions:** Static scapular upward rotation was measured on the throwing dominant arm with a digital protractor while subjects were at rest and at 60ˆ, 90 and 120 of humeral elevation in the scapular plane on two consecutive days. The root of the scapular spine and the posterolateral acromion were palpated and used as landmarks for the measurements. Three trials were performed at each position with a 30 second rest period between each trial. Order of position was randomized during each of the two days. The three upward rotation measurements at each position were averaged for each day. **Main Outcome Measures:** The RCI

was calculated according to the Jacobson method of quantifying clinically significant change by dividing the change in measurements between test days on the outcome measure by the standard error of difference score. Intraclass correlation coefficients (ICC) were needed to complete the RCI calculation. An RCI was calculated for the four positions of humeral elevation (rest, 60°, 90°, and 120°). **Results:** The mean scapular upward rotation at rest was 0.04 ± 2.46° with an ICC of 0.97 and an RCI of 3.84°. At 60°, the mean was 7.72 ± 4.42° with an ICC of 0.89 and an RCI of 0.92°. At 90°, the mean was 18.57 ± 4.69° with an ICC of 0.92 and an RCI of 6.31°. At 120°, the mean was 31.84 ± 5.17° with an ICC of 0.95 and an RCI of 3.77°. **Conclusions:** The results of this study provide clinicians with baseline values for normal scapular upward rotation, reliability of the measurements and RCIs to identify clinically significant changes. These measurements may provide clinicians with reference values to identify potentially pathological shoulder movements in order to distinguish true differences from slight variation normally associated with a repeated measurement. Future research should compare these results to patients with scapular dysfunction and intervention protocols used to treat scapular dyskinesis.

A Modified Digital Inclinometer Is A Valid Instrument For Measuring Scapular Anterior-Posterior Tilt In Shoulder Injured Subjects

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Context: Using electromagnetic tracking systems, investigators have been able to quantify tri-planar scapular kinematics in healthy and shoulder injured subjects. Modified digital inclinometers have been validated for the assessment of scapular upward rotation. While evidence suggests that scapular anterior-posterior (AP) tilt is also an important factor to consider when treating shoulder injured patients, no clinical instruments have been validated for this purpose. **Objective:** The purpose of this study was to test the hypothesis that measurements of scapular AP tilt obtained using a modified digital inclinometer would produce valid results when compared to measures acquired using an electromagnetic tracking system in shoulder injured subjects. **Design:** Quasi-experimental, correlational design. **Setting:** Controlled laboratory environment. **Patients or Other Participants:** Nineteen volunteers (20.42 ± 1.92 years; 1.77 ± 0.09 meters; 85.13 ± 23.11 kg; 10 males, 9 females), with either a current or a history of shoulder injury (43.89 ± 31.18 months, ranging from 1 to 96 months). All subjects underwent an evaluation to confirm shoulder injury status. **Intervention:** Shoulder kinematic data were collected using the MotionStar electromagnetic tracking system (Ascension Technology, Burlington, VT), and Motion Monitor software (Innovative Sports Training, Chicago, IL). Anatomic and reference coordinate systems approved by the International Society of Biomechanics were used to calculate position, orientation and displacement of the scapula. Scapular AP tilt was measured using a modified digital inclinometer that has been validated (r = 0.63 - 0.86) and in which intra-rater ($ICC_{(3,2)}$ = 0.86 – 0.99) and inter-rater reliability ($ICC_{(2,2)}$ = 0.83 - 0.92) have been previously established for healthy shoulders. All data collection involved the injured shoulder. Subjects performed three trials of 0°, 30°, 45°, 60°, 90°, and 120° of humeral elevation in the scapular plane in a randomized fashion. **Main Outcome Measures:** The dependent variable was scapular AP tilt. Criterion-related validity of the inclinometer was assessed via Pearson Product Moment correlations. SPSS version 17.0 was used for the statistical analyses. An $a = 0.05$ was set *a priori*. **Results:** Correlation analyses revealed significant moderate to good correlations (r = 0.68 - 0.76, $p < 0.001$) for clinically relevant combinations of humeral elevation. The coefficients of determination revealed that 45-58% of the error variance could be accounted for by common factors involving the two devices. **Conclusions:** The results of this study indicate that the modified digital inclinometer is a valid method for assessing scapular AP tilt in shoulder injured patients. Use of the modified digital inclinometer will enhance our ability to affordably monitor in-vivo scapular AP tilt in the clinical environment. Further modifications to the inclinometer may be warranted to address the error between the devices. This study was fully funded by the Eastern Athletic Trainers' Association, Inc.

Mechanical Laxity Testing In Those With Chronic Ankle Instability: An Evidence Based Approach

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Context: Chronic ankle instability (CAI) commonly develops following lateral ankle sprain. There is limited consensus concerning the role mechanical laxity plays in those with CAI. Additionally, it has not been established if clinical orthopedic tests are comparable to instrumented arthrometry. **Objective**: To determine if instrumented and manual talar tilt tests have diagnostic utility in CAI populations. **Design**: Cross-sectional. **Setting**: Biomechanics Research Laboratory. **Patients or Other Participants**: Seventy-four recreationally active participants with varying degrees of ankle function (41 females, 33 males, mean age±standard deviation 21.0±2.4years, height 169.57±9.97cm, mass 69.86± 13.60kg). **Interventions**: In a single test session participants completed the Cumberland Ankle Instability Tool (CAIT) and an ankle injury history questionnaire. Mechanical laxity testing consisted of instrumented arthrometer inversion talar tilt tests (ML) and manual medial talar tilt stress tests for laxity (TT). Sensitivity, specificity, positive likelihood ratio (LR+) and negative likelihood ratio (LR-) were calculated to assess the ability of both laxity tests to correctly diagnose CAI. **Main Outcome Measures**: A CAI group was identified as those with history of lateral ankle sprain, e"2 reported episodes of ankle instability in the last 12 months, and a CAIT score d"26. The non-CAI group was those with a CAIT score e"28 and no history of instability in the past 12 months Based on previous literature, hypermobility was denoted with ML of >29.4°. For TT, a scale of 1-5 was used; scores of 4 and 5 were labeled hypermobile. Sensitivity, specificity, LR+ and LR- were calculated for both ML and TT in those diagnosed with CAI and non-CAI participants via the aforementioned criteria. **Results**: Non-CAI participants (N=37) had CAIT scores of 29.6±0.7, while CAI participants (N=37) had 19.9±5.2. For ML, non-CAI participants had 16.47°±10.37° and CAI participants had 22.94°±11.16° inversion. For ML sensitivity=0.33 (95%CI: 0.20, 0.50), specificity=0.86 (95%CI: 0.72, 0.94), LR+=2.45 (95%CI: 0.97, 6.30) and LR-=0.77 (95%CI: 0.59, 1.00). For TT, sensitivity=0.50 (95%CI: 0.34, 0.66), specificity=0.81 (95%CI: 0.66, 0.90), LR+=2.64 (95%CI: 1.26, 5.55) and LR-=0.62 (95%CI: 0.43, 0.89). **Conclusions**: The results indicate mechanical laxity testing has some diagnostic value for evaluating CAI. The high specificity revealed a positive laxity test suggests a high degree of likelihood that one has CAI. The results also indicate clinicians can effectively identify participants' laxity through manual testing. This finding is important in clinical settings due to limited access to instrumented arthrometers. Currently, the "gold standard" for evaluating CAI is limited to self-report questionnaires and past medical history. Objective measures of CAI may be necessary for researchers to increase homogeneity among group membership. The few false positives in both mechanical laxity tests imply clinical usefulness and it is suggested CAI be evaluated through a wide range of quantitative and qualitative tools.

Identifying Clinically Important Observed Gait Abnormalities

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Context: Gait assessment is an important component of many evaluations. There are multiple methods available for clinicians to use for gait assessment. The most common method relies on observation of patients while walking or running rather than the more expensive use of force plates and 3D cameras. Because methods and philosophical approaches to assessment vary greatly, there is a need for standardized gait assessment. **Objective:** To identify observed gait abnormalities perceived as clinically important and the corresponding assessment parameters commonly used by clinicians for each. **Design:** Survey. **Setting:** An online survey was administered through Patient Reported Outcomes Measurement Information System (PROMIS). **Participants:** Fourteen licensed and currently practicing athletic trainers (mean±SD: age = 26 ± 9.1 yrs; 6 male, 8 female; experience = 4 ± 12.2 yrs) volunteered to serve as content experts (CE). For tool development, 10-15 CE are typically needed. **Interventions:** The Gait Abnormalities: Clinical Importance Survey (GACIS) was developed based on 60 gait abnormalities identified in the literature. Twenty of the 60 abnormalities were eliminated primarily due to repetitive definitions using varied nomenclature and a few were considered unfeasible. The remaining 40 abnormalities were identified for GACIS and pilot tested for readability. Prior to the completion of GACIS, definitions of each phase were provided. CE were asked to rate the clinical importance of each gait abnormality on a scale of 1 to 5 (least to most clinical importance).

Subsequently, CE identified the plane of view (anterior, posterior, or lateral) and gait velocity (walking, jogging, or running) used to observe each abnormality. **Main Outcome Measures:** The variables evaluated in the survey include clinical importance, plane of view, and gait velocity for each of the 40 abnormalities. A mean of 3.5 or greater was used to determine abnormalities with perceived clinical importance. A consensus of at least 75 percent among CE was used to determine the consistency of the plane of view and gait velocity observation parameters. **Results:** Twenty-two of the 40 gait abnormalities were considered to be clinically important. CE varied in their opinions of which plane of view should be observed for 18/22 clinically important abnormalities, agreeing on only 4/22 abnormalities. CE agreed that 11/22 abnormalities should be observed while the patient is walking; opinions varied for the type of velocity that should be used to observe the remaining 11/22 abnormalities. **Conclusions:** CE agreed upon 22 gait abnormalities that are clinically important when conducting gait assessment, but had varied opinions of which plane of view and gait velocity were optimal to observe these abnormalities. This lack of consensus creates a challenge for testing the inter-rater and intra-rater reliability of clinicians in the assessment of gait abnormalities for the development of a gait assessment screening tool.

Reliability Of Injury Risk Prediction Algorithm Across Three Different Institutions: Implications For Multi-Center Biomechanical And Epidemiological Research

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Context: Multi-center collaborations for prospective, longitudinal investigations provide an appealing alternative to single-center studies. A multi-center approach has the capacity to generate large sample sizes and thus generate more generalizable and statistically powerful results. Studies that investigate difficult or rare phenomena as their primary outcome of interest, such as ACL injury, may particularly benefit from this approach. The biomechanical variables that contribute to a predictive nomogram for knee injury have been validated and established as reliable at a single center. However, the utility and translatability of these tests across multiple institutions has not been assessed. **Objective:** To assess the within- and between-center reliability of an affordable, clinically-based risk factors that utilize two-dimensional (2D), camcorder-based methods to screen young athletes for high risk of knee injury at three institutions. We hypothesized that the 2D screening methods would provide good-to-excellent reliability within and between institutions for frontal and sagittal plane biomechanics and variables that contribute to nomogram-predicted high knee abduction loads. **Design:** Multi-center laboratory reliability study. Setting: School and Controlled laboratory. **Patients or Other Participants:** Nineteen (19) female, varsity and junior varsity level high school volleyball players participated in this study (Mean age ± SD, 15.27 ± 1.0 years; height, 1.69 ± 0.42 m; mass, 61.08 ± 7.9 kg).. **Interventions:** 2D motion capture techniques were used to collect kinematics of the lower extremity during a drop vertical jump task. The subjects were tested as a group at each testing center on separate dates within a three week period. **Main Outcome Measures:** Within-center and between-center reliability were assessed with intra-class and inter-class correlation coefficients (ICCs). **Results:** Within-center reliability of the variables that comprise the clinical nomogram was consistently classified as excellent, but between-center reliability was classified as fair-to-good. The within-center ICCs for all nomogram variables combined was 0.98 (ICC range 0.95-0.99), while combined between-center ICC was 0.63 (ICC range 0.51-0.78). The

average typical error for frontal plane knee excursion was 2.3 cm for within-center comparisons and 2.5 cm for between-center comparisons, with no discernible side-to-side differences. The average typical error for knee flexion range of motion was 5.9° for within-center comparisons and 6.7° for between-center comparisons. **Conclusions:** The risk screening protocols were reliable within centers and repeatable between centers. Additional efforts to increase between-center investigator training and further standardize methodologies may reduce between-center error during biomechanical assessments, and further enhance reliability. The current results demonstrate the feasibility of multi-site biomechanical studies and establish a framework for the further dissemination of injury risk screening algorithms for young athletes. Specifically, the proposed multi-center studies may allow for validation and optimization of readily accessible and inexpensive 2D camcorder based screening tools to identify young and underserved female athletes at high risk for knee injury.

Reliability And Validity Of Hand-Held Dynamometry Assessment Of Hip Abduction Strength In Healthy, Young Adults

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Context: Hip musculature weakness, specifically of the hip abductors (HABD), has been associated with numerous musculoskeletal pathologies. Screening of hip strength during pre-participation examination may be important in the prevention of lower extremity injury. Hand-held dynamometers (HHD) are a convenient and relatively inexpensive clinical tool that can estimate muscle strength. In addition, a strap to stabilize the HHD and address bias associated with tester strength has been utilized in recent investigations. Limited data exists on the accuracy of HHD assessment compared to the gold standard of isokinetic dynamometry (ID). **Objective**: To determine the intersession and interrater reliability, as well as the validity of the HHD in measuring HA strength in sidelying (SL) and supine (S) positions, both with (SLW, SW) and without a stability strap (SLWO, SWO). **Design:** Controlled laboratory. **Setting:** Research laboratory. **Participants:** Fourteen healthy, young adults (4M, 19.25±2.5yrs; 178.44±6cm, 70.31±7.64kg; 10F, 23.6±2.01yrs; 166.88±5.62cm, 65.14±11.05kg). **Intervention:** Participants volunteered and reported for two sessions one week apart. At each session, two raters, both certified athletic trainers, performed assessments in SL and S positions. During the no strap condition the raters performed a manual muscle test holding the HHD. During the strap condition, the volunteer pushed against the HHD secured with a strap. Four, 5-second trials were performed during each condition, with appropriate rest between trials, conditions, and raters. Additionally, at the first session, HABD strength was also measured using the ID, utilizing the same protocol as the HHD for trials and rest. **Main Outcome Measures:** Raw force values were converted to torque values using the appropriate moment arms and reported in Nm. $ICC_{2,2}$ models were calculated for interrater and intersession reliability for each condition. Pearson Correlation coefficients were calculated for validity between each HHD condition and the ID measure. **Results:** There was strong interrater reliability for the SW ($ICC_{2,2}$=0.989; 95%CI:0.965-0.996), SWO ($ICC_{2,2}$=0.929; 95%CI:0.778-0.977), SLW ($ICC_{2,2}$=.986; 95%CI:0.956-0.995), SLWO conditions ($ICC_{2,2}$=0.963; 95%CI: 0.884-0.988). Additionally, there was strong intersession reliability for the SW ($ICC_{2,2}$=0.958; 95%CI:0.870-0.987), SWO ($ICC_{2,2}$=0.964; 95%CI:0.889-0.989), SLW ($ICC_{2,2}$= 0.983; 95%CI:0.948-0.995), and SLWO conditions ($ICC_{2,2}$=0.967; 95%CI:0.896-0.989).There were strong, positive correlations between the HHD and SW (r=0.921,p<.01), SWO (r=0.917,p<.01), SLW (r=0.882,p<.01), and SLWO conditions (r=0.852,p<.01). **Conclusion:** The HHD had strong interrater and intersession reliability for HABD strength assessment in two testing positions, both with and without a strap. Additionally, there was a strong correlation between the ID and HHD for HABD strength. The HHD appears to be a valid and reliable tool for clinicians in assessing HABD strength.

Reliability And Validity Of M-Mode Ultrasound Measurements Of Quadriceps Femoris Contractile Time

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Context: Recruitment and timing of the quadriceps femoris (QF) muscle is often impaired with knee dysfunction. Real time ultrasound imaging (RTUS) is a non-invasive rehabilitative technology to assess skeletal muscle and its contractile performance. **Objective:** To determine the reliability and validity of RTUS M-mode temporal measurements of QF contractile time (CT). **Design:** Reliability and concurrent validity design. Setting: Outcome measures were assessed in a university research laboratory. **Participants:** Twenty healthy participants (Eleven female, nine male, age=22.6±4.5, height =168.5±7.5 cm, mass=70±7 kg) were assessed for reliability. Nineteen healthy participants (fifteen female, four male, age=20.9±1.5, height=170.8±7.8 cm, mass= 71.5±11.7 kg) were assessed for concurrent validity. Interventions: RTUS M-mode intra-rater, inter-rater, and test-retest reliability of isometric QF CT by two different investigators was compared during two testing sessions 4-7 days apart. RTUS M-mode concurrent validity of isometric QF CT was correlated to isometric time to peak torque on an electromechanical dynamometer in another session. **Main Outcome Measures:** M-mode RTUS was used to measure longitudinal muscle thickness of the distal vastus medialis oblique (VMO), rectus femoris/vastus intermedius together (RF-VI), and vastus lateralis (VL). CT was the time interval from muscle thickness at rest to the muscle thickness in a maximal voluntary isometric contraction. Three trials were assessed for each location of each reliability measure in knee extension and each correlation of time to peak torque at 60° knee flexion. Intraclass correlation coefficients (ICC) were used to measure reliability and Pearson correlation coefficients (= 0.01) were used to analyze time to peak torque relationships. **Results:** The measurement method had excellent intra-rater reliability for the VMO ($ICC_{2,12}$ rater 1=0.95, 95% CI=0.90-0.98; rater 2=0.91, 95% CI=0.84-0.96), RF-VI ($ICC_{2,12}$ rater 1=0.97, 95% CI=0.95-0.99; rater 2=0.91, 95% CI=0.83-0.96), and VL ($ICC_{2,12}$ rater 1=0.96, 95% CI=0.93-0.98; rater 2=0.94, 95% CI=0.89-0.97); excellent inter-rater reliability for the VMO ($ICC_{3,6}$ session 1=0.95, 95% CI=0.91-0.98; session 2=0.92, 95% CI=0.86-0.96), RF-VI ($ICC_{3,6}$ session 1=0.94, 95% CI=0.89-0.97; session 2=0.96, 95% CI=0.93-0.98), and VL ($ICC_{3,6}$ session 1=0.95, 95% CI=0.90-0.98; session 2=0.96, 95% CI=0.93-0.98); and excellent test-retest reliability for the VMO ($ICC_{2,24}$=0.96, 95% CI=0.93-0.98), RF-VI ($ICC_{2,24}$=0.97, 95% CI=0.95-0.99), and VL ($ICC_{2,24}$=0.97, 95% CI=0.95-0.99). Mean reliability CT of the VMO=70 ms, RF-VI=68 ms, and VL=72 ms. A strong correlation between VMO RTUS CT and time to peak torque was significant ($r(43)=0.62$, $P<0.001$). A strong correlation between RF-VI RTUS CT and time to peak torque was significant ($r(38)=0.61$, $P<0.001$). A medium correlation between VL RTUS CT and time to peak torque was significant ($r(53)=0.42$, $P=0.001$). Mean validity RTUS CT of the VMO=92 ms, RF-VI=92 ms, and VL=93 ms. Mean validity time to peak torque of the VMO=290 ms, RF-VI=300 ms, and VL=310 ms. **Conclusions:** This study describes a new reliable and valid alternative measurement method of QF timing with M-mode RTUS.

sEMG Onset Method Selection Affects Reliability Estimates And Statistical Outcomes

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Context: Methods to determine surface electromyography (sEMG) onset criterion scores are susceptible to measurement error which can affect statistical outcomes. Limited peer-reviewed data examines the dependence of outcomes and subsequent inferences on onset method selection. **Objective:** To quantify reliability estimates of, and determine how statistical outcomes and inferences are affected by, three literature-based methods for determining sEMG pre-activation onset. **Design:** Repeated measures. **Setting:** Research laboratory. **Patients or Other Participants:** A convenience sample of active females (n=10, 24±2.3 yrs, mass 65±10 kg, height 165±6.3 cm) without pregnancy or illness affecting balance volunteered to participate. **Interventions:** Participants stepped down from a standardized height (7.5") onto impact-resistant polyurethane foams of pre-determined thicknesses (independent variable; 0", ¼", ½", 1", 2"). sEMG data were collected (1kHz, BIOPAC Systems) in tibialis anterior (TA), lateral gastrocnemius (LG), and vastus medialis (VM) muscles. Each of the five conditions was repeated 10 times, ensemble averaged, and root-mean squared. Pre-activation onset was determined by the following methods: (1) regression line (RL), (2) visual inspection (V), and (3) three standard deviation threshold method (TH). **Main Outcome Measures:** Calculated reliability estimates for sEMG onset time included coefficient of variation (CV), intraclass correlation coefficient (ICC(2,1) and (2,k)), as well as standard error of measurement (SEM) (ICC and SEM

for 0" only). The continuous dependent outcomes, sEMG pre-activation duration (ms) and mean amplitude (mV), were determined for each method-muscle combination. Six (3 muscles x 2 outcomes) separate multivariate one-way repeated measure analyses of variance were performed. Alpha was set at $p<.05$. **Results:** In terms of reliability, CV ranged from CV_{RL}=18-69% (35±11%), CV_{V}=24-37% (29±4%), and CV_{Th}=18-47% (27±11%), non-uniformly across muscles or thicknesses. ICC(2,1) values ranged from R_{RL} =.130-.547(.378±.2), R_{V} =.531-.688(.594±.1), and R_{TH}=.471-.995(.804±.3). ICC(2,k) comparing the three onset methods yielded R_{TA}=.077, R_{LG}=.754 and R_{VM}=.766. SEM values ranged from SEM_{RL}=84-99 ms (89±10 ms), SEM_{V}=51-72 ms (61±10 ms), and SEM_{Th}=7-66 ms (30±30 ms). As for statistical outcomes, RL produced a statistically significant decreasing trend in LG mean amplitude with increasing thickness (p=.017). V indicated a decreasing trend in LG mean amplitude (p=.022), as well as a within effect (p=.042) and an increasing trend (p=.017) in duration. There were no significant differences for TH. **Conclusions:** Comparing RL, V, and TH, the magnitude of CV range was equivocal; however, the reliability estimates (i.e. SEM, ICC(2,1)) were low for RL and between methods (ICC(2,k)). Statistical outcomes and inferences regarding the relationship between foam thickness and sEMG variables were influenced by onset determination method. Even when reliability was similar (LG: ICC(2,1)) between methods, each of the three methods provided unique outcomes for a given muscle-thickness combination and interpretation varied. Therefore, without robust estimates of reliability for a relevant muscle and movement task, the use of any onset method is cautioned.

Assessment Of Quadriceps Activation Via Burst Superimposition In A Closed Chain Position: A Novel Approach

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Context: Central activation ratio (CAR) is used to estimate volitional quadriceps activation during a maximal voluntary isometric contraction (MVIC). CAR values are typically calculated from force data during an open-kinetic-chain knee extension task. Variability in CAR values exists based on the technique used for performing MVIC. Assessing quadriceps activation in a closed-kinetic-chain (CKC) position is a novel approach. **Objective**: The primary objective was to determine the test-retest reliability of the quadriceps CAR in a closed-kinetic-chain position. **Design**: Crossover, controlled laboratory study. **Setting**: Research laboratory. **Patients or Other Participants**: 25 healthy participants (13 men, 12 women; age = 23.8 ± 3 years; height = 72.7 ± 14.5 cm; mass = 175.3 ± 9.6 kg) volunteered. **Interventions**: Participants completed two sessions with a minimum of 48 hours between, in a test-retest fashion. Burst superimposition (SIB) testing was performed bilaterally in a CKC position. Verbal technique-based instruction was given, directing the participant to focus on quadriceps contraction, maintain upright posture with appropriate contact between trunk and back of the chair, and exhale while contracting with arms across chest. Participants were firmly secured to a dynamometer during testing. **Main Outcome Measures**: Quadriceps CAR via the SIB technique and knee extension MVIC torque were the primary outcome measures of interest. CAR was measured via the SIB technique, and calculated as (MVIC/SIB)*100. Mean MVIC and SIB torque were normalized to body mass. The intra-class correlation coefficient ($ICC_{2,k}$) and Bland-Altman plot were used to assess inter-session reliability and agreement among quadriceps CAR in a CKC position between sessions. Two separate paired samples t-tests were used to evaluate differences between sessions for CAR and MVIC torque. **Results**: Inter-session reliability was moderate for quadriceps CAR ($ICC_{2,k}$) = 0.68, ($F_{21,22}$ = 3.12, P = 0.005). CAR did not significantly differ between sessions (Session 1: 81.4 ± 11.5%, Session 2: 84.2 ± 8.5%; $t_{21,.975}$ = -1.13, P = 0.27). Bland-Altman plots revealed a mean CAR difference between sessions of -2.5 ± 10.3% (LOA -23.1 to 18.1%). Knee extension MVIC torque was significantly greater on Session 2 (Session 1: 1.28 ± 0.40 Nm/kg; Session 2: 1.48 ± 0.44 Nm/kg; t_{21} = -2.21, P = 0.038). **Conclusions**: CAR calculated via burst superimposition is moderately reliable in a closed-kinetic-chain position with technique-based instruction. Observed differences in knee extension torque in the absence of CAR differences may indicate a learned effect between sessions, as technique-based instruction was provided. Quadriceps CAR calculated in a CKC position may provide a more accurate representation of muscle activity during function. Further consideration should be given to determine the reliability over a greater period of time to account for the possibility of a learning effect.

Development Of The Self-Efficacy Of Balance Scale (SEBS) For Young Active Individuals

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Context: Research suggests that injury risk reduction is not feasible without behavioral change. Neuromuscular assessment techniques used to identify balance deficits associated with the risk of lower extremity(LE) injuries exist; however tools to assess psychological risk factors for LE injuries are not currently available. Self-efficacy of balance, a psychological characteristic, may provide information regarding psychological risk factors for LE injury. Validated instruments to assess self-efficacy of balance do not currently exist. **Objective:** Determine the face and content validity of the Self-Efficacy of Balance Scale(SEBS) for an adolescent population. **Design:** Cross sectional **Setting:** Conducted survey via electronic questionnaires. **Patients or Other Participants:** Eleven content experts participated (10 athletic trainers(ATs) with clinical and research expertise of LE injuries, 1 expert in self-efficacy research were assigned to 2 panels). Interventions: Panel 1 (5 ATs, 1 self-efficacy expert) assessed 17 items for face validity to determine if each item accurately assessed an adolescent individual's confidence in the ability to balance during athletic activities. The panel also had the opportunity to add, delete, or suggest edits for wording or clarity. The scale was edited to reflect Panel 1 recommendations, including adding three items. Items suggested for deletion were flagged for potential removal. Panel 2 was instructed to assess content validity by determining whether each item on the new scale was 'essential,' 'useful, but not essential,' or 'not necessary' to the performance of assessing self-efficacy of balance. **Main Outcome Measures:** Feedback from Panel 1 was used to evaluate face validity, meaning each item was perceived to test confidence in balance in a young, active population. Responses obtained from Panel 2 were used to assess content validity by calculating a Content Validity Ratio(CVR) and Content Validity Index(CVI), the mean for all retained items. Items with a CVR<0, (majority of panelists did not agree the item was essential) or a CVR=0 (only half of the panel agreed the item was essential) were flagged for potential removal. **Results:** The original 17-item scale was revised to 21 items, reflecting suggestions made by Panel 1. Assessment of content validity revealed 16 items reached a positive CVR agreement (majority of panelists rated the item to be 'essential'). A CVR of 0 was indicated for five items. The CVI was 0.46. Items that reached a positive CVR were retained and items with a CVR of 0 were flagged for further testing. **Conclusions:** Face validity of the SEBS has been established. Furthermore, panelists were able to validate the content of the SEBS. Further analyses are necessary to determine construct and convergent validity, resulting in an objective psychological measure for balance. Future use of the SEBS may provide important insights into how balance self-efficacy in young, active individuals affects risk of LE injury.

Contractile Impulse Differences Between The Sexes During Time Critical Periods

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Context: Contractile impulse, the area under the torque-time curve, is an important strength measure because, unlike many other strength measures, it incorporates the time history of a contraction. During time critical situations, which present the potential for injury such as the initial 50 and/or 100 ms following ground contact, rapid torque development is likely necessary to control joint motion and to provide dynamic joint stabilization. Despite its importance and relevance to lower extremity injury, little information regarding contractile impulse differences between the sexes exists. **Objective:** To compare isometric contractile impulses between the sexes. **Design:** Cross-sectional. **Setting:** Research laboratory. **Patients or Other Participants:** Twenty-one healthy, physically active volunteers (12 Males, 9 Females, Age: 20.91 ± 1.55 years, Height: 1.70 ± 0.10 m, Mass: 72.76 ± 11.31 kg). **Interventions:** Isometric plantarflexion torque-time curves of the dominant limb were recorded using a Biodex System 3 dynamometer in terfaced with a Biopac MP100 data collection system. Testing position was standardized so that all participants were seated recumbently, the foot secured to a footplate attached to the dynamometer, and the ankle and knee joints positioned in neutral and 60º of flexion, respectively. Participants were instructed to isometrically plantarflex as hard and fast against the footplate as possible following the presentation of a light stimulus. Three trials with 60 seconds of rest between

trials were performed. **Main Outcome Measures:** Contractile impulse was calculated by integrating the area under the torque-time curve during the initial 50ms (CI-50) and 100ms (CI-100) following torque onset. Onset was defined as the instant when the torque signal exceeded 2.5% of the recorded peak torque. The mean values across trials for each subject were normalized to the product of body mass and height (BM*Ht). Differences in the CI-50 and CI-100 between sexes were assessed using one-tailed, independent t-tests (d•0.05). **Results:** Males demonstrated significantly greater CI-50 (Males: 0.0030 ± 0.0011 Nm0s*(BM*Ht)-1 vs. Females: 0.0021 ± 0.0011 Nm0s*(BM*Ht)-1; p=0.049) and CI-100 (Males: 0.0123 ± 0.0043 Nm0s*(BM*Ht)-1 vs. Females 0.0087 ± 0.0045 Nm0s*(BM*Ht)-1; p=0.041) than females. **Conclusions:** Previous reports have suggested peak torque and rate of torque development differences between the sexes. The current results suggest sex differences in joint work capability during time critical periods in which control of joint motion and dynamic stabilization are essential. As such, the assessment of CI may be useful for characterizing neuromuscular function over short timeframes likely pertinent to injury. Further research is needed to determine if these results hold true in other muscle groups.

An Investigation Of Concussion-Related Neuroproteins In Collegiate Athletes: A Comparison Of Gender Differences In High-Risk Sports

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Context: In the United States, more than 1.6 million sport-related concussion injuries occur annually, with the majority resulting from contact sports such as football and soccer; research reports the highest incidence for female athletes in the sport of soccer. Neuropsychological evidence-based guidelines stand to aid in diagnosis of severity and return to play (RTP) decisions. In addition, sport-concussion in early-adulthood has been correlated with neurodegeneration resulting in impaired movement and memory later in life. **Objective**: To identify if physiological biomarkers (neuro-proteins) associated with concussion and sub-concussive blows due to participation in high-risk sports of football and soccer differ based on gender. **Design:** Longitudinal repeated measures, mixed design. **Setting**: Controlled laboratory environment. **Patients or Other Participants**: Volunteer sample of collegiate athletes (age = 19.45 ± 1.51 years, years in college sport = 2.18 ± 1.47; N=100, 76% male, 24% female), including football (n=76) and soccer athletes (n= 24) were recruited through sport team meetings to gather baseline blood neuroproteins and demographic information. **Inter-ventions**: Blood was drawn into two red top vacutainers from veins in the cubital fossa at 1500 hours on three separate week days. The blood was allowed to clot and was spun down to separate plasma from serum. A pipette transferred serum and plasma into five sets of cryovials and stored at -80°F. Samples were kept frozen until sent to the lab for testing. Data gathered were analyzed using One-way ANOVA and descriptive analyses. **Main Outcome Measures**: The following neuro-proteins were measured in the blood samples: ANGF-2, FGF-Basic, HGF, IL-8, PDGF-BB, TIMP-1, TIMP-2, TNFa, and VEG-F. These markers were chosen as the literature suggests they relate to inflammation and neurological tissue damage. One-way ANOVA compared theses biomarkers by gender. **Results**: One-way ANOVA analyses produced a significant difference in PDGF-BB [$F_{(1,98)}$=8.81, p=.004, ˜ $^{2=}$.369] between males (M=1420.04 ± 483.04) and females (M=1114.47 ± 250.70). **Conclusions**: Our analyses revealed a significant difference in PDGF-BB with male football athletes having increased levels in comparison to female soccer athletes. PDGF-BB, platelet-derived growth factor, is a protein that regulates cell growth and division. Athletes in the current sample participated in high-risk contact sport and were likely to have experienced unreported concussion or multiple sub-concussive events during sport participation. While yet in the novel stages, the identification of higher levels of DGF-BB in males should be examined further to solidify the relationship between concussive events and brain healing across genders. In addition, the exploration of diagnostic biomarkers could prove vital to understanding immediate and delayed neural damage associated with concussion and is promising for the field of athletic training.

Comparisons of Performance On A Clinical Test Of Reaction Time Between Sport And Sex

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Context: Recently, much attention has been given to the importance of proper evaluation of concussions in order to combat the short- and long-term effects on neurocognitive and psychomotor function. Using a battery of tests has been suggested to be most effective for diagnosing concussion and guiding return to play decisions. Sex differences in pre- and post-concussion assessments have been reported for several tests. Recently, a novel test for assessing clinical reaction time (RTclin) (Eckner et al, 2010) was presented as a simple and clinician-friendly test to evaluate psychomotor function. However, as this work was primarily performed with football players, it is unknown whether normative data from this group is accurately representative of a broader population of athletes. Further, it is unknown whether sex differences exist in the performance of this test. **Objective**: To examine performance of RTclin across multiple sports and to explore potential sex differences in RTclin in healthy collegiate athletes. **Design**: Descriptive Cohort. **Setting**: Controlled Laboratory. **Patients or Other Participants**: 68 football (1.9±0.7m, 94.9±15.8kg, 19.1±1.6yrs), 96 soccer (46F: 1.6±0.6m, 60.3±10.9kg, 19.1±1.2yrs; 50M: 1.8±0.7m, 71.3±8.4kg, 19.8±1.8yrs), and 29 basketball (12F: 1.8±0.1m, 70.7±23.7kg, 19.2±1.0yrs; 17M: 1.9±0.9m, 87.6±12.7kg, 19.4±1.0yrs) NCAA Division I and Community College athletes with no current concussion symptoms or injury to the dominant upper extremity. **Interventions**: While sitting in a standardized position with their dominant forearm resting on a table, subjects performed 6 trials of a preseason baseline test of RTclin (Eckner et al., 2010) by catching a measuring apparatus as quickly as possible after it was unexpectedly dropped by a researcher. The distance the apparatus fell before being caught was measured (cm). **Main Outcome Measures**: The average distance (cm) across the middle four trials was converted to RTclin (ms). A one-way ANOVA compared RTclin between all sports. Independent t-tests then compared soccer and basketball males and females on RTclin. **Results**: There were no differences in RTclin ($F_{2,191}$= 1.41, p=0.25) between football (197.2±7.9ms), soccer (199.2±7.9ms) or basketball (198.2±5.1ms) athletes. Females displayed significantly faster (t_{123}=-2.2, p=0.03) RTclin than males (197.4±6.1ms vs. 200.3±8.1ms). **Conclusions**: Current findings indicate that performance during a baseline test of RTclin is similar across sports, which may aid in future interpretability of existing normative data. When stratifying by sex, it appears that females performed better than males. However, the clinical significance of this finding (i.e. 3ms difference) remains unclear. Overall, the findings point positively to the potential utility of this test. Given its simplicity, this test may be most valuable for ATˆs with limited resources and time. Further work is needed to validate this test against other established testing protocols and also to investigate this test in a younger population. Future investigations should also evaluate potential sex differences in RTclin during post-concussion follow-ups.

Evaluation Of Supplemental Football Helmet Protection

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Context: Efforts to reduce the incidence of sports-related concussion have elicited aftermarket, supplemental protection for helmets. Products claim substantial additive effects to football helmet performance parameters which are purported to reduce the brain injury of concussion. However, neither product systems nor the components have been validated by peer-reviewed literature. **Objective:** To characterize and evaluate the impact attenuation of a supplemental helmet protection system. **Design:** Post-test only control group design. **Setting:** Research laboratory. **Patients/Other Participants:** Kevlar® fiber mesh, polyurethane-based foam system (Kevlar-PUFoam) (n=6), Kevlar fiber mesh component (Kevlar) (n=6), and polyurethane-based foam component (PUFoam) (n=6). **Interventions:** Impact tests were performed against (1) a flat steel anvil (Anvil) or (2) with the addition of a helmet surrogate plaque-foam system (PF) comprised of a stacked injection molded 1/8" helmet outer shell-grade material plaque atop 1" VN600 foam using an instrumented drop tower (Dynatup 9250HV, Instron, Norwood, MA) at 5.5 m/sec with a 4.9 kg drop weight containing a rounded polyurethane dart (150M, Lixie Hammers, Central Falls, RI). For impact setups 1 and 2, four sample conditions were evaluated: A) Control, B) Kevlar, C) PUFoam, and D) Kevlar-PUFoam. The control condition was devoid of supplemental technology. Two separate one-way ANOVAs were performed with post-hoc Tukey HSD tests, where alpha was set a priori to ˜=.05. **Main Outcome Measures:** Peak impact force (PIF) and percent change in severity index compared to control condition (%SI). **Results:** For setup 1, mean PIF were: $Anvil_A$ (13975 N ±245), $Anvil_B$ (13345 N ±205), $Anvil_C$ (12779 N ± 181), and $Anvil_D$ (12624 N ± 145). Significant main effects were observed for PIF ($F_{3,8}$=28.86, p<.01, f=3.28). $Anvil_A$ was greater than $Anvil_B$, $Anvil_C$, and $Anvil_D$ (p=.019, p<.001, p<.001), respectively. $Anvil_B$ was greater than $Anvil_C$ (p=.033) and $Anvil_D$ (p=.009). For setup 2, mean PIF were: PF_A (5340 N ±47), PF_B (5093 N ±89), PF_C (4835 N ±41), and PF_D (4798 N ±38). Significant main effects were observed for PIF ($F_{3,8}$=42.79, p< .01, f=3.99). PF_A was greater than PF_B, PF_C, and PF_D (p=.008, p<.001, p<.001), respectively. PF_B was greater than PF_C (p=.006) and PF_D (p=.003). Mean %SI were calculated to be PF_B (-4.2%), PF_C (-7.0%), and PF_D (-7.2%). **Conclusions:** Addition of the Kevlar-PUFoam product to a helmet surrogate statistically reduced PIF and subsequently decreased SI, which provided support to the impact protection product claims. However, no differences between the Kevlar-PUFoam and the PUFoam component suggested that the polyurethane-based foam provided the primary linear, compressive impact management mechanism. Finally, supplemental protection to the inner liner of a helmet should lower PIF and better SI, but clinicians should be cautious when recommending such systems as no scientific information is available to address the clinical significance of these products.

Forward Head Posture Increases The Risk Of Crown Of The Head Impacts In Football

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Context: Forward head posture (FHP) is the anterior translation of the head in the sagittal plane relative to the trunk. Football athletes with FHP may be less able to resist the draw of gravity causing them to have a tendency to lower the head prior to contact. Objective: 1) To compare the risk of sustaining impacts to the back, front, side, and top of the head between athletes with and without FHP. 2) To compare the risk of sustaining mild, moderate, and severe head impacts between athletes with and without FHP. **Design:** Prospective quasi-experimental. Setting: Clinic/On-field. Patients or Other Participants: Thirty-three high school football players were categorized into either the non-FHP group (n=18; height=180.2±7.4 cm; mass=94.0±20.6 kg) or the non-FHP group (n=15; height=180.5±7.4 cm; mass=77.8±12.9 kg) based on previously published FHP cutoffs. Interventions: Participants stood in front of a leveled marker, marched in place five times, squatted once, and were instructed to stand looking straight ahead in a natural resting position. Three sagittal still images were captured for each player from 200 cm distance. Images were leveled and digitized. Forward head angle was measured as the angle between a reflective marker placed over C7, the tragus, and the horizontal. We used the Head Impact Telemetry System to record head impact biomechanics at all practices and games (FHP: n=8,079; Non-FHP: n=6,035 head impacts). Main Outcome Measures: 1) We identified the location (back, front, side, top) using measures of elevation and azimuth captured for each head impact. Relative risks for sustaining impacts to the back, front,

side, and top of head were computed for the FHP group relative to the Non-FHP group. 2) Using previously published values, the linear and rotational acceleration of each head impact was categorized as mild (d•66g; d•4600 rad/s^2), moderate (>66g or <106g; 4600> or <7900 rad/s^2), or severe (e"106g; e"7900 rad/s^2). Relative risks of sustaining mild, moderate, and severe head impacts were computed for the FHP group relative to the Non-FHP group. **Results:** Players with FHP were at an increased risk of sustaining impacts to the top of the head (RR=1.76, 95%CI:1.61-1.92) and,conse-quently, a reduced risk of sustaining impacts to the back (RR=0.82, 95%CI:0.77-0.87) and front (RR=0.91, 95%CI:0.87-0.94) of the head. Players with a FHP were at a reduced risk of sustaining both moderate (RR=0.64, 95%CI:0.53-0.78) and severe (RR=0.55, 95%CI:0.32-0.95) rotational head impacts. **Conclusions:** High school football players with FHP may have a propensity to lower the head prior to collision rather than utilizing a heads-up tackling technique. Loading through the spine may reduce resultant rotational acceleration of the head, but poses a serious threat to the cervical vertebrae if in a flexed position. Football players may benefit from interventions aimed at correcting posture.

Effect Of Ball Speed During Soccer Heading On Concussion Assessment Scores

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Context: Due to the increasing popularity of soccer in the US, the numbers of brain injury due to repetitive head impact have also increased. Certified athletic trainers have used sideline concussion tests to indicate whether or not an athlete has impairments that can be indicative of a concussion. Soccer heading ball speeds may influence injury risk, but have not been evaluated in a controlled, yet functional, setting. **Objective:** To determine the influence of soccer heading ball speed on concussion sideline assessment scores. **Design:** Pre-test post-test repeated measures research design. **Setting:** Athletic training laboratory and gymnasium. **Participants:** Sixteen current division one collegiate soccer players (age= 20.4 ± .96; M = 10; F = 6) with no history of head or neck injury in 6 months prior to testing, no braces on their teeth, and at least 5 years of soccer heading experience participated. **Intervention:** The independent variables were ball speed (30, 40, and 50mph; randomized) and time (pretest vs. posttest). Ball speed was a between-subjects factor (30mph n = 5, 40mph n = 5, 50mph n = 6) and time was a repeated-measure. Soccer balls were projected from a JUGS soccer machine at 30, 40 and 50 mph. Subjects performed at least 5 standing headers at their respective ball speeds. Concussion assessments were performed approximately 1 week prior to and immediately post soccer headings. **Main Outcome Measures:** Sideline concussion assessments included the Standard Concussion Assessment Tool 2 (SCAT2), Balance Error Scoring System Score (BESS), and King Devick Test (KDT). Group (3) by time (2) MANOVAs and ANOVAs with repeated measures on time were performed using SPSS v19, $p \leq .05$. **Results**: There were no statistically significant differences between ball speed groups on any concussion assessment measures over time. There was a statistically significant main effect, $F(1,13) = 9.08$, $p = .010$, in KDT for time where the posttest KDT time (37.6 ± 6.8 sec) was lower than the pretest (40.0 ± 5.1 sec). Slight symptoms (1 of 6 severity endorsed), such as headache, pressure in the head, neck pain, and fatigue, were elicited post-heading in some players during the SCAT2 evaluation. **Conclusions:** Heading a soccer ball at 30, 40, 50 mph did not cause statistically significant increases in concussion assessment scores. The KDT significant result in overall time could be attributed to a learning effect. Although no statistically significant results were identified in the concussion assessments over time, slight symptoms were elicited in some players post heading. These transient slight symptoms following high-speed head impacts in sports are common, but their significance is not well understood. Sports medicine health care professionals need to remain proactive and conservative in their concussion management strategies.

Balance And Cognitive Performance Under A Divided Attention Task Prior To And Following Two Different 4-Week Training Interventions: Preliminary Implications For Concussion Rehabilitation

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Context: Concussion rehabilitation has emerged as a priority among clinicians tasked with caring for brain-injured athletes. Little evidence exists on the utility and feasibility of concussion rehabilitation paradigms. **Objective**: To examine differences in cognitive and balance performance under a divided attention paradigm prior to and following a dual-task or a single-task training intervention in healthy individuals. We hypothesized that the dual-task group would have greater improvements in divided attention performance following the intervention. **Design**: Prospective cohort with stratified (gender), randomized intervention group assignment (dual-task or single-task). **Setting**: Clinical research center. **Patients or Other Participants**: A convenience sample of 30 healthy, recreational athletes (15 male, 15 female; 15 dual-task, 15 single task) served as participants (age=20.3±1.9 yrs; height=1.7±0.2 m; mass= 68.3±13.8 kg). **Interventions**: Intervention group (dual-task vs. single task) and test-session (pre-intervention vs. post-intervention) served as independent variables. All participants completed a divided attention assessment including a concurrent balance and cognitive exam prior to and following the interventions. Both groups completed a 4-week mass progression intervention program (3x per week including 1 home session). Individuals in the dual-task group performed balance and cognitive activities concurrently (e.g. concentration task while performing a single leg balance task) during training sessions while the single-task group performed activities separately. **Main Outcome Measures**: Outcomes included Sensory Organization Test (SOT) eyes-open equilibrium scores (conditions 1, 3, 4, and 6) and complex attention reaction times for correct responses on an incongruent Stroop task assessed individually and under a divided attention paradigm. All outcomes were assessed pre- and post-intervention (time between assessments=34.0±4.2 days). Mixed model ANOVAs were used to examine all measures (˜=0.05 *a priori*). **Results**: Following intervention, divided attention reaction times were faster ($F_{1,26}$=5.03; P=0.033) in the single-task group (pre=643.6±60.7 ms; post= 611.7 ±64.5 ms) and slower in the dual-task group (pre= 569.4±198.6 ms; post=612.4 ±212.1 ms). Divided attention balance scores improved between pre- and post-intervention for all four SOT condition equilibrium scores in both groups (Condition 1: pre=89.8±6.3 vs. post=92.8±3.1, P=0.011; Condition 3: pre=89.3±3.9 vs. post=91.4±3.3, P=0.005; Condition 4: pre=81.9±8.4 vs. post=85.9±6.2, P<0.001; Condition 6: pre=71.0±12.9 vs. post=74.2±6.2, P=0.045). No test-session effect was observed for divided attention reaction time (P=0.477). No group or interaction effects were observed for any of the SOT condition scores. No cost differences to balance or cognitive performance under the divided attention task compared to the single task were observed. Participants were able to comply with the interventions. **Conclusions**: Divided attention balance performance improved regardless of intervention group. Single task complex attention training appears to lead to greater improvements during a divided attention task. Both paradigms may be feasible for rehabilitation programs. Future research should address applications of more advanced dual-task rehabilitation paradigms aqnd the effects on divided attention in the management of concussed individuals. This study was funded by NCTraCS. The NCTraCS Institute is supported by grants UL1TR000083, KL2TR000084, TL1TR000085 from the National Center for Advancing Translational Sciences, National Institutes of Health.

A Descriptive Analysis Of Clinical Findings At Discharge Following Sport-Related Concussion: A Report From The Athletic Training Practice-Based Research Network

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Context: With many concussion state laws, the return-to-play decision (RTP) is restricted to qualified healthcare providers, including athletic trainers (ATs). While ATs are educated and trained to manage concussive injuries, it is unknown whether ATs are following current recommended RTP guidelines in clinical practice. **Objective**: To describe the course of clinical recovery and the rationale of RTP decision-making at discharge following a sport-related concussion. **Design**: Retrospective analysis of electronic medical records (EMR). **Setting**: Athletic Training Practice-Based Research Network (AT-PBRN). **Patients or Other Participants**: Discharge records of 188 patients (141 males, 47 females, age= 16.7±1.7) diagnosed with a concussion by an AT. **Interventions**: Patient records from the period of October 2009-October 2012 were reviewed. All records were created by an AT utilizing a web-based EMR within the AT-PBRN. Concussed patients were identified by concussion-specific diagnostic codes (ICD-9: 850.0, 850.5, 850.9). **Main Outcome Measures**: Frequency and descriptive statistics were calculated for each variable of interest from the discharge form: diagnostic code, recovery time, delayed onset of symptoms, course of recovery, time loss, primary decision-maker, concussion classification system, and criteria guiding return-to-play decisions. **Results**: The majority of cases were coded as 850.9-Concussion (77.1%, n=145) with fewer being coded as 850.0-Concussion mental confusion without loss of consciousness (20.2%, n=38), and 850.5-Concussion with loss of consciousness (2.7%, n=5). The majority occurred in football (63.6% n=119) and soccer (12.2%, n=23). Only 11.7% (n=22) were considered normal within 15 minutes and 26.1% (n=49) reported delayed onset of symptoms after the concussion. Most (97.8%, n=184) were not allowed to RTP on the day of injury. While the majority of concussions recovered gradually (symptoms present for 1-7 days) (51.1%, n=96), recovery in other cases was rapid (symptoms present <1 day) (13.3%, n=25), prolonged (symptoms present for >7 days) (31.9%, n=60), or with persistent symptoms (symptoms present at end of season) (3.2%, n=6). Time lost from competition was 14.5±17.6 days and patients were symptom free for 7.8±10.3 days prior to returning to competition. Eight percent (n=15) of patients were disqualified for the remainder of the season. The athletic trainer served as the primary decision-maker for the patient in 69.7% (n=131) of cases and the majority of cases (70.2%, n=132) were not graded with a classification system. RTP guidelines were used in 77.1% (n=145) of cases, with the Zurich progression (36.2%, n=68) cited most frequently. **Conclusions**: The vast majority of concussed patients did not RTP on the day of the injury, following current recommendations and many state laws. The majority of cases had symptom resolution within 7 days, indicating a relatively quick recovery. The decisions by the majority of ATs to not grade the concussion and to use a RTP progression concur with current recommendations, suggesting ATs are following best practices.

Decreased Sport-Related Concussion Incident Rates Following Intervention At The Middle School Football Level: Case Series

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Background: Sport-related concussions have the highest incidence in football. According to injury surveillance study from 2005-2006, practice and competition injury rates of concussions at the high school football level are 2.54 and 12.09 rate of injury per 1000-athlete exposures, respectively. The prevalence of sport-related concussions has not been defined at the middle school football level. In this case series, four middle school football players (age range 11-12 years old, all males) sustained sport-related concussions during practice (n=3) and at competition (n=1). No loss of consciousness occurred; all athletes were given an on-field concussion evaluation by the athletic trainer and then referred for further evaluation by a physician, based on NATA Position Statement: Management of Sport-Related Concussions. The mechanism of all four concussions was the same with either head-to-head or head-to-person contact; specifically all tackles lead with the head. Common chief complaints were headache, nausea, and dizziness, lasting on average four days. **Treatment**: All cases received physician clearance at one week and successfully progressed through a return to play protocol following a concussion and were able to return to full completion two weeks following onset. Recognizing the commonality between these three cases, covering a period of one week, and observing in practice that athletes were leading with the head during tackles, the Athletic Trainer advised proper hitting mechanics should be taught. The athletic trainer approached the first-year middle school head coach

regarding the need to correct the improper hitting mechanics, especially in those of the younger athletes. The football coach expressed disbelief and stated if the athletic trainer felt such, she could make the changes herself. All three levels (6^{th}-8^{th} grade) were spoken to as a group regarding the severity and implications of concussions by the Athletic Trainer. The Athletic Trainer then explained and demonstrated proper hitting mechanics – athletic position, leading with the facemask looking at the numbers of the opponent, wrap up, keep the feet moving and tackle the opponent. The coach divided the team by grade level and further demonstrated proper hitting mechanics. Following the demonstration, athletes began practicing supervised hitting, 6.25 athletes to 1 coach. The Athletic Trainer floated around to assist coaches. Two days of practice (3 hours total) were devoted to specific hitting and tacking drills, progressing from one-on-one to live play, emphasizing the basics. **Results**: Three sport-related concussions were sustained within the first five days of full-pads practice. Following the intervention, the incident rate dropped from 8.33 to 0.434 per 1000-athlete exposures over a course of two-months. **Uniqueness**: The role of an athletic trainer has been well defined at assessing and treating athletic injuries, as well as preventing them. This case series illustrates the importance of this role in recognizing potential athletic injuries and implementing an intervention. This case demonstrates the coach and Athletic Trainer can work together to reduce injury rates. **Conclusions**: Although the incidence rate of concussions is not known at the middle school level it obviously occurs. This series demonstrates teamwork between a coach and the Athletic Trainer to emphasize proper hitting mechanics. Although the coach initially did not believe there was a problem, the effort and enthusiasm displayed by the Athletic Trainer influenced the coach to dedicate a significant amount of practice to improve hitting technique. Although concussions are acknowledged at the national level, further emphasis on the risks and severity of concussions needs to be done at the fundamental level. The incidence of sport-related concussions in this case series was decreased after the Athletic Trainer identified the improper hitting mechanics and worked with the coaches to address a problem with a positive result of reduced incidence.

No Factorial Validity Support For Revised Baseline And Injured Factor Structures Of Response To PCSS

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Context: A recent study published in 2012, provided "revised" factor structures for both non-injured (baseline) and injured (concussed) responses to the 22-item, ImPACT© Post Concussion Symptom Scale (PCSS). Employing Exploratory Factor Analysis (EFA), the study suggested that both samples of responses maintained four symptom-clusters. However, the symptom-clusters and construct definitions not only varied from previously reported factor structures, but also between baseline and concussed responses. The strength of inferences drawn from composite scores depends upon the quality and quantity of available validity evidence. Such evidence to support the proposed use of the PCSS composite scores is minimal. However, 4-factor measurement models have been suggested by a few studies employing EFA methods (e.g., PCA). Thus, more rigorous confirmation is warranted. **Objective:** To confirm the factorial validity of the 4-factor response structures of both non-concussed and concussed athlete responses to the PCSS found within the ImPACT© computerized neurocognitive exam. **Design:** Retrospective Analysis **Settings:** University Laboratory. **Participants:** Non-concussed (N=908) and concussed athletes (N=146) enrolled at a southeastern Division I institution. **Interventions:** Baseline and concussed responses to the 22-item PCSS instrument. **Main Outcome Measures:** Two separate Confirmatory Factor Analyses (CFAs) (i.e., one CFA with baseline data set and the other CFA with injured sample)

were performed to fit the specified PCSS model, for which the baseline was hypothesized as 4-factor with 20/22 items (i.e., Cognitive-Sensory, Affective, Vestibular-Somatic, and Sleep-Arousal) and the injured sample as 4-factor with 17/22 items (i.e., Cognitive-Migraine-Fatigue, Affective, Somatic, and Sleep). Several model fit indexes were employed, including $\tilde{}^2$, $\tilde{}^2/df$, CFI, and RMSEA. **Results:** The first data set (N = 908) with baseline was subject to a CFA. Goodness of fit indices revealed that the 4-factor model did not fit the data well ($\tilde{}^2$ = 2350.04; $\tilde{}^2/df$ = .164; CFI = .670; RMSEA = .600). Goodness of fit indices for the injured sample (N=146) revealed that the injured responses to the 4-factor PCSS model also did not fit the data well ($\tilde{}^2$ = 369.03; $\tilde{}^2/df$ = .113; CFI = .809; RMSEA = .12). **Conclusion:** Responses of both non-concussed and concussed athletes failed to support the posited 4-factor measurement model of the PCSS. Such evidence severely reduces the strength of inferences that can be drawn from the clinical use of the four symptom clusters within the PCSS. Clinicians should be cautioned before using a composite score from the 22-item PCSS or its constituent clusters in prognosis.

A Comparison Of Emergency Facemask And Helmet Removal Effectiveness With Various Football Helmets And Facemask Attachment Systems

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Context: The National Athletic Trainers' Association recommends facemask removal (FMR) for emergency access to football players' airways with limited research comparing helmet removal (HR) and FMR. Recent changes in football helmet and facemask designs have implemented quick-release systems aimed at reducing FMR time. Comparing the relative efficacy of these two new systems to access the airway during FMR and HR tasks has not yet been investigated. **Objective:** To compare the amount of head movement, time to task completion, and perceived difficulty during FMR and HR across two different helmet designs. We hypothesized that FMR would result in less motion, time to task completion, and perceived difficulty than HR. **Design:** Quasi-experimental. **Setting:** Research laboratory. **Patients or Other Participants:** Forty athletic trainers (ATs) free of physical pathology preventing them from completing the required tasks were recruited (males=21; females=19; age= 33.7±11.2 yrs; mass=80.7±17.1 kg; height=173.1±9.2 cm; AT experience =10.6±10.4 yrs). **Interventions:** Independent variables consisted of helmet (Riddell Speed 360—RS360—or Schutt ION 4D—ION4D) and technique (facemask removal vs. helmet removal). After familiarization, paired participants conducted 4 successful trials in random order for each of four helmet-technique conditions (RS360-FMR; RS360-HR; ION4D-FMR; ION4D-HR). An eight-camera three-dimensional motion system and two, three-point segment marker sets (head and torso) were used to record head motion in a live model wearing properly fitted helmets and shoulder pads. Total time was recorded with a digital stopwatch. The difficulty for the task reported by the participant was recorded after each trial using a modified Borg CR-10 scale. **Main Outcome Measures:** Dependent variables included motion, total time and perceived difficulty. A 2x2 (helmet x technique) within-subjects repeated measures ANOVA was employed for each dependent variable (Pd•0.05). Due to our participant pairing, our analyses were based on a sample of n=20. **Results:** We observed a significant helmet-by-technique interaction ($F_{1,19}$=349.12; P=0.001); RS360-FMR took longer (31.22±7.89 s) than ION4D-FMR (20.45±3.57 s) or ION4D-HR (26.40±6.29). Helmet removal (sagittal: 14.88±2.48ˆ; frontal: 7.00±1.14ˆ; transverse: 7.00±1.08ˆ) resulted in greater motion than FMR (sagittal: 7.04±1.80ˆ; frontal: 4.73±1.14ˆ; transverse: 4.49±0.89ˆ) in all three planes of motion (sagittal: $F_{1,19}$=187.27; frontal: $F_{1,19}$=65.34; transverse: $F_{1,19}$=68.36; P<0.001 for all). Our ATs reported equal task difficulty across both helmet designs and airway access techniques ($F_{1,19}$=0.56; P=0.462). **Conclusions:** As hypothesized, FMR induced less motion than HR when accessing the airway, validating current clinical recommendations. Quick-release loop straps allow FMR to be completed in clinically acceptable times with less motion in all planes. Future research should continue to examine the effects of helmet designs on emergency airway access. This study was funded by the Eastern Athletic Trainers' Association.

Head And Trunk Acceleration During Intermediate Transport On Medical Utility Vehicles

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Context: Medical utility vehicles are used for intermediate transport of athletes with suspected catastrophic neck injuries from the field to an ambulance. Various vehicles differ in their axle suspension systems, axle location relative to patient position, and bi-axle distance. **Objective:** To analyze and compare neck motion during transport on two different medical utility vehicles. **Design:** Within subject. **Setting:** Controlled laboratory. **Patients or Other Participants:** Nineteen males (21.8±1.4 years, 176.5±5.5 cm, 90.3±16.1 kg) with no previous history of injury to the spinal column. **Interventions:** Participants were secured to a spine board and stretcher using standard protocols and loaded onto one of two medical utility vehicles: Husqvarna HUV 4421DXL ambulance (HUV) or modified John Deere Gator TH (Gator). Vehicles were driven 60 yards; consisting of 30 yards of artificial turf transitioning to concrete slab (Interval 1) then 30 yards of concrete slab transitioning to natural grass (Interval 2). Subjects completed three counterbalanced trials for each vehicle. Vehicle speed was standardized (6.46-7.22 mph) using an infrared timing system. During the trials, three-dimensional accelerometers (Noraxon USA Inc., Scottsdale, AZ) recorded peak head and trunk acceleration data in the sagittal, frontal and transverse planes. For each plane, absolute peak acceleration of the trunk was subtracted from the absolute peak acceleration of the head to yield peak acceleration differences. For each vehicle, the peak acceleration differences for the three trials were averaged. The independent variables were the vehicle (HUV and Gator) and interval (Interval 1 and Interval 2). **Main Outcome Measures:** The dependent variables were the average peak acceleration differences in the three planes (sagittal, frontal and transverse). The influence of vehicle and interval on the average peak acceleration differences was compared using a two-within factors ANOVA (*P*d"0.05). Tukey post hoc testing was applied in the event of a significant interaction. **Results:** Main effects were detected in the frontal plane for vehicle ($F_{1,36}$=4.93; *P*=0.033) and interval ($F_{1,36}$=20.27; *P*<0.001); in that the Gator (6.55±3.46m/s/s) was greater than the HUV (4.80±3.52m/s/s) and Interval 2 (7.16±4.2m/s/s) was greater than Interval 1 (4.19±1.94m/s/s). A main effect was detected in the transverse plane for interval ($F_{1,36}$=4.1; *P*=0.05) in which Interval 1 (4.08±2.2m/s/s) was greater than Interval 2 (3.23±2.00m/s/s). There was an interaction for the transverse plane ($F_{1,36}$=18.01; *P*<0.001) in which the HUV during Interval 1 (5.27±2.32m/s/s) was greater than the Gator during Interval 1 (2.90±1.30m/s/s) and HUV during Interval 2 (2.63±1.76m/s/s). There were no main effects for the sagittal plane. **Conclusions:** Differences in relative accelerations exist in the frontal and transverse planes in healthy spine-boarded participants who are secured to different intermediate transport vehicles. This suggests differences in surface-type and vehicle specifications create lateral and vertical perturbations that may be conveyed to the patient.

The Influence Of Mood State On ImPACT Baseline Test Performance

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Context: Baseline assessments using computerized neuropsychological (CNP) testing has been advocated for the management of sport concussion. ImPACT is a commonly used CNP test used in sport concussion management protocols. A potential extraneous variable which may influence baseline ImPACT test performance is mood. Sources of random error such as mood may limit the clinical utility of the baseline ImPACT assessment following sport concussion. **Objective:** To examine the effect of mood state on ImPACT performance in a healthy collegiate sample. **Design:** Repeated Measures. **Setting:** Research laboratory. **Patients or Other Participants:** One hundred and four (32 males and 72 females) healthy college students aged 20.9 ± 1.45 years participated in this study. **Interventions:** Participants completed the Profile of Mood States Brief Form (POMS-B) prior to completing ImPACT at three clinically relevant time points (days 1, 45, and 50). The Green's Word Memory Test (WMT) was also delivered to assess effort. **Main Outcome Measure:** Pearson correlation coefficients were calculated for each of the seven POMS-B factors (fatigue-inertia, vigor-activity, tension-anxiety, depression-dejection, confusion-bewilderment, anger-hostility and total mood disturbance) and ImPACT composite and symptom scores. Repeated measures analysis of variance (ANOVA) was used to

determine significant differences across time in regards to POMS-B, ImPACT, and Green's WMT composite scores. Greenhouse-Geisser corrections were used to correct for violations of sphericity. Post-hoc analyses were performed using dependent *t* tests. All analyses were performed with = .05. **Results:** Our analyses revealed significant differences across time for composite ImPACT verbal memory (Wilk's = .824, $F_{(2,214)}$ = 10.86, $p < .001$) and visual motor speed (Wilk's = .867 $F_{(2,214)}$ = 7.80, p = .001). Post hoc analyses revealed significant improvements between day 1 and day 45 ($t_{(103)}$ = -4.0, $p < .001$) and day 1and day 50 ($t_{(103)}$ = -4.39, $p < .001$). Significant improvements were also observed for visual motor speed between day 1 and day 45 ($t_{(103)}$ = -2.00, p = .05), day 1 and day 50 ($t_{(103)}$ = -3.965, $p < .001$) and between day 45 and 50 ($t_{(103)}$ = -2.378, p = .02). At time point 1 ImPACT impulse control was significantly correlated to POMS-B fatigue-inertia (-.228, p = .02). ImPACT's total symptom score was most consistently correlated to multiple POMS-B factors with correlations coefficients ranging from -.23 to .57. No additional significant correlations were observed between the remaining ImPACT composite scores and the varying mood states. **Conclusions:** Our results suggest that although mood factors as measured by the POMS-B were significantly correlated to total symptom score of ImPACT, performance remained either consistent or improved over time. Future research is needed in a collegiate athlete sample to determine if potentially higher mood state values influence computerized neuropsychological test results.

Baseline SCAT2 Scores In Middle And Secondary School Student-Athletes

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Context: The Sport and Concussion Assessment Tool 2 (SCAT2) is recommended to assess post concussion neurocognitive and balance ability. The components of the SCAT2 have demonstrated face and content validity, but the use has primarily been incorporated into college and adult populations. SCAT2 has been suggested for use in children as young as 10 years old. Representative baseline scores have only been reported for high-school and college-aged student-athletes. To date there are no published data on representative baseline scores in the middle-school level. **Objective:** To determine normal baseline SCAT2 scores for middle school athletes and compare scores by age and gender. **Design:** Cross sectional. **Setting**: Single private high-school and middle-school (grades 7-12). **Participants:** 324 student-athletes (170 males, 154 females, age=14.44±1.74) completed the SCAT2 as a part of pre-participation screening. **Intervention:** Baseline SCAT2 scores were individually obtained in a quiet setting. Scores were grouped by age (12-18 years old) at the time of the test and rounded to the nearest whole year. Descriptive statistics were reported by age and gender using separate ANOVAs ($p<0.05$) and Tukey's post hoc testing were reported used to identify differences between age. **Main Outcome Measures:** Maximum scores are: SCAT2 (100) symptom score (22), sign score (2), GSC (15), BESS (30), coordination (1) and total SAC (30) as well as its four individual subcomponents (orientation (5), immediate memory (15), concentration (5), delayed recall (5)). Points are awarded for correct responses or deducted for symptom scores (22 minus number of symptoms) or poor GCS responses. **Results:** There were no statistical differences on gender between SCAT2 scores (F=0.0326, p=0.569, females=91.9±4.9, males=91.6±4.5. All subjects scored 100% for GCS and the subcomponent sign score. Females reported more symptoms (F=12.56, p<0.000, female= 19.6±3.2, males= 20.7±2)(lower scores=more symptoms), higher BESS scores (F=6.89, p=0.009, females=27.3±2.2, males=26.5±3.1), and higher SAC immediate recall scores (F=9.705, p=0.002, females=14.6±0.9, males= 14.2±1.3). Comparison by age identified a significant difference (F=2.77, p=0.012) in the concentration subscale. Tukey's Post Hoc testing reported 12 year olds (3.2±1.3) scored lower than 15 year olds (3.8±1.0) and 16 year olds (3.9±1.1) (p=0.048 and p=0.043 respectively). **Conclusion:** The SCAT2 test is a widely used concussion assessment tool that has been recommended for children as young as 10 year old. Subcomponents of the SCAT2 test show differences between gender and age. Consideration should be given for demographic differences in middle school athletes, with baseline testing being conducted annually. Additional data from multiple sites is needed to determine normalized values for both the SCAT2 test and the subcomponents. SCAT2 tests should be used in conjunction with other tests in scholastic age student-athletes to make return to play decisions.

An Examination Of Risk Factors For Sport Related Concussion In High School Football Players

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Context: Approximately 40,000 Sport Related Concussions (SRC) occur annually in high school football. To date, most epidemiologic studies of SRC have not reported variables that may be associated with increased risk of SRC in this population. **Objective:** Determine the association of various intrinsic and demographic factors with the incidence of SRC in high school football players. **Design:** Prospective cohort. **Setting:** Data were collected by Athletic Trainers (ATCs) at 36 public and private high schools in Wisconsin during the 2012 football season. **Participants:** A convenience sample of 1,332 football players (grades 9 – 12, age: 15.9 $\pm$ 1.8 yrs, BMI: 24.3 $\pm$ 4.3, with 4.1 $\pm$ 1.0 years of football experience) enrolled in this study. **Interventions**: During the pre-season, subjects completed a questionnaire to measure age, height, weight, year in school, level of competition, years of football experience and SRC history. ATCs at each school recorded the incidence of SRC throughout the season. **Main Outcome Measures:** Dependent variables included the incidence of SRC. T-tests were used to compare the incidence of SRC for age and BMI. Chi-square tests were used to compare the incidence of SRC among grade, competition levels, years experience, and history of SRC. Relative Risks [RR, 95% CI] were calculated for variables with significant tests ($p < .05$). **Results:** A total of 115 (8.6%) players sustained 116 SRCs. No differences were found in the age ($p = 0.587$) and BMI ($p = 0.490$) of players who sustained an SRC compared to their non-injured peers. There was no difference in the rate of SRC (%, 95% CI) by year in school [$p = 0.896$], (freshmen (8.4, 5.9 -11.9), sophomores (8.8, 6.0-12.5), juniors (9.5, 6.7-13.2) and seniors (7.8, 5.1-11.6), or competition level [$p = 0.768$], (freshmen (8.8, 6.1 -12.5), junior varsity (9.4, 6.7-13.0) and varsity (8.1, 6.2-10.6), or previous playing experience [$p = 0.205$], (0 to 2 years (9.7, 6.6 -14.1), 3 to 5 years (9.5, 7.4 -12.0) and 6 to 8 years (6.6, 4.5 -9.6). The rate of SRC was higher [RR = 2.21, 1.54 – 3.17] in players with a history of SRC (15.5, 11.4 - 20.8) than players without a history of SRC (7.0, 5.6-8.8), [$p < 0.001$]. **Conclusion:** Increased risk of SRC was not associated with a player's age, BMI, grade in school, level of competition or years of football experience. However, players with a history of SRC were twice as likely to sustain an SRC compared to players without a history of SRC. ATCs need to screen for SRC history to identify those high school football players at increased risk of SRC.

Prior Concussion History And Newly Diagnosed Concussions Are Elevated Among Students With Self-Reported Learning Disability And Attention Deficit Hyperactivity Disorder

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Context: Concussion management relies on clinical judgment exercised on an individualized basis. Clinical judgment includes considering the patient's personal and medical history. Learning disabilities (LD) and attention deficit hyperactivity disorder (ADHD) have both been identified as potential modifying factors that warrant consideration when assessing an athlete with a concussion. However, little research exists regarding the potential impact of LD and ADHD on the likelihood of sustaining a concussion.**Objective**: To investigate the relationship between self-reported learning disability (LD) or attention deficit hyperactivity disorder (ADHD) and self-reported history of concussion and sustaining a diagnosed concussion. **Design**: Prospective cohort. **Setting**: High school athletic training facilities. **Patients or Other Participants**: A convenience sample of 8811 adolescent athletes (2809 females, 6002 males, age=15.7±1.2 years, grade=9.3±1.1 level) participating in interscholastic contact sports. **Interventions**: All subjects completed the Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT), as part of a concussion baseline assessment protocol. Independent variables included self-reported LD or ADHD, as determined by the participants' responses to questions about LD and ADHD within the ImPACT demographic section. Any participant sustaining a concussion during this 2-year prospective study completed ImPACT within 48 hours of the concussion and serially during

recovery as indicated by their respective athletic trainer. **Main Outcome Measures**: Dependent variables included the self-reported history of prior concussion as documented in the ImPACT demographic section and any subsequent concussion diagnosed by an athletic trainer that resulted in the participant completing at least one post-injury ImPACT test. The relationship between each independent and dependent variable was evaluated with separate Chi-Square analyses (P<.05). **Results**: A total of 158 participants (1.8%) indicated they had LDs; 375 (4.3%) noted they had been diagnosed with ADHD, and 1583 (18.0%) reported a prior history of concussion. A total of 632 concussions (incidence=7.2%) were diagnosed during the 2-year study period. Self-reported LD was significantly associated with a higher report of prior concussions (p<.001, 31.6% vs. 17.7%) and diagnosed concussions (p<.001, 14.6% vs. 7.0%). Likewise, participants with self-reported ADHD were more likely to report a prior history of concussions (p<.001, 27.7% vs. 17.5%) and sustain a newly diagnosed concussion (p<.001, 12.8% vs. 6.9%). **Conclusions**: These findings suggest that self-reported LD and ADHD are both associated with a higher rate of prior concussion and newly, athletic trainer-diagnosed concussion. Athletic trainers should ask about and document these comorbid factors as part of the pre-participation examination and consider them in assessing the potential for concussion, and the management of concussed athletes. Future studies should investigate the mechanisms underlying the increased rate of concussion associated with LD and ADHD. Funded by a grant from the National Operating Committee on Standards for Athletic Equipment (NOCSAE).

Increasing The Interpretability Of Patient-Rated Outcome Measures For Evaluating Concussed Patients

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Context: A limitation of using patient-rated outcome instruments (PROMs) with injured athlete populations, such as those suffering concussion, is lack of information to guide interpretation of scores. Scores indicative of improvement have not been defined for the PedsQL, MFS, and HIT-6 PROMs, limiting the ability to accurately interpret scores as patients recover from injury. Identifying a score cutpoint that defines athletes as improved or unimproved in the days following concussion would increase PROMs' clinical utility. **Objective**: To estimate a score for concussion PROMs that accurately classifies athletes as improved or unimproved at days 3 (D3) and 10 (D10) post-concussion. **Design**: Pre-post, within-subject. **Setting**: Secondary school athletic training facilities. **Patients or Other Participants**: 218 adolescent athletes who sustained a concussion diagnosed by their athletic trainer (184 males, 34 females, age=15.7±1.1 years, grade=10.0±1.0 level). **Interventions**: Patients completed the Pediatric Quality of Life Inventory (PedsQL), PedsQL Multidimensional Fatigue Scale (MFS), Headache Impact Test (HIT-6), and Global Rating of Change (GROC) on D3 and D10 post-concussion. **Main Outcome Measures**: Dependent variables include the PedsQL total score, 3 subscale scores of the MFS [general (MFS-GF), sleep (MFS-SLF), and cognitive (MFS-CF) fatigue], and the HIT-6 total score. Higher scores on HIT-6 and lower scores on PedsQL and MFS indicate lower HRQOL. The GROC, scored as 1=very much worse; 15= very much better, was used to ascertain the patient-perceived magnitude of change in health status since concussion. Patients were dichotomized as improved (GROC 'much better' or higher) or unimproved (GROC less than 'much better') on D3 and D10. Improvement was determined through receiver operator characteristic curves by identifying the point of maximum sensitivity and 1-specificity. Area under the curve (AUC) determined discriminative ability of the improvement cutpoint, with values $\geq$0.70 considered satisfactory. Means and standard deviations are reported for PROMs. Cutpoint data are presented as (cutpoint, AUC). **Results**: At D3, 106 patients were classified as improved (PedsQL total=92.7±8.3; MFS-GF=88.0±14.1; MFS-SLF= 82.8±18.1; MFS-CF=84.8±16.0; HIT-6 total=56.0±7.7) and 110 as unimproved (PedsQL total= 79.8±12.1; MFS-GF=62.5±23.0; MFS-SLF=60.6±24.1; MFS-CF=61.9 ±23.7; HIT-6 total=46.6±7.4). PROM cutpoints and AUC values at D3 were: PedsQL total=89, .83; MFS-GF=73, .83; MFS-SLF=77, .78; MFS-CF=77, .78; and HIT-6 total=51, .81. At D10, 187 patients were defined as improved (PedsQL total=94.4±8.2; MFS-GF=91.7±14.4; MFS-SLF=89.1 ±14.2; MFS-CF=89.1±15.7; HIT-6 total=46.0±8.6) and 25 as unimproved (PedsQL total=79.0±13.4; MFS-GF=69.0±24.7; MFS-SLF=70.8 ±18.8; MFS-CF=64.7±25.2; HIT-6 total=59.0±6.6). PROM cutpoints and AUC values at D10 were: PedsQL total=92, .86; MFS-GF=85, .79; MFS-SLF=90, .79; MFS-CF= 85, .82; and HIT-6 total=53, .87. **Conclusions**: Our results define PedsQL, MFS, and HIT-6 scores as they relate to improvement following concussive injuries. All cutpoints suggest greater than 70% probability of correctly classifying concussed patients as improved as demonstrated by greater than satisfactory AUC values. These cutpoints should help clinicians better

interpret concussion PROMs and manage concussed patients overtime.

Closed Traumatic Head Injury In A High School Football Athlete

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Background: Athlete is a 17 year-old Caucasian male high school football linebacker. The athlete's medical history revealed an episode of acute pancreatitis within the past year. Athlete was on punt return team when he made helmet to helmet contact and fell to the ground creating a second head impact. Athlete walked off the field on his own volition. Athlete reported to Certified Athletic Trainer (ATC) complaining of headache and dizziness. He denied any nausea or other symptoms. ATC began side-line examination which consisted of clearing any neck pathologies through palpations and evaluations of extremity myotomes and dermatomes. In addition, he was assessed for a concussion and vital signs were monitored. Within concussion assessment, ATC noted cranial nerve function WNL, Standardized Assessment of Concussion (SAC) test 21/30, and Balance Error Scoring System (BESS) revealed balance deficits. Athlete was removed from competition with clinical examination leading to diagnosis of concussion. Immediate plan of care was discussed with parent and educational materials describing potential signs and symptoms requiring immediate referral were provided to the parent for further monitoring. ATC continued to monitor the athlete for changes in status throughout the competition. During the half-time, athlete reported to ATC and admitted that he had immediately vomited after initial head trauma. With the updated athlete history of vomiting, the ATC, in consultation with his parent, immediately referred the athlete to the ER. Differential Diagnosis: Cervical Neck Pathology, Transient Brian Injury, Concussion, Subdural Hematoma Treatment: Athlete reported to ER and attending physician ordered a CT scan. CT Scan revealed a left periventricular hemorrhage. The athlete was admitted to the hospital for overnight observations. Athlete had follow-up CT scan the next day which demonstrated no exacerbation of focal bleed; thus, released from hospital. Athlete was scheduled for follow-up appointment two weeks following the release from hospital. Athlete returned to school following the weekend and completed post-concussion assessment including, SAC test, BESS, and Immediate Post-Concussion Assessment and Cognitive Test (ImPACT) which revealed a statistically significant deviation from baseline. Athlete reported daily to ATC for monitoring, completion of symptom cards, and updates on his status. The athlete's symptoms included dizziness, sensitivity to light, and nausea lasting five days in duration. Athlete continued to be withheld from competition. At the subsequent 2 week follow-up with neurologist, repeat CT Scan revealed that the periventricular hemorrhage had re-absorbed and thus cleared to full participation by the neurologist. ATC administered follow-up ImPACT test where athlete was at baseline and per District School policy, athlete was allowed to begin four-day progressive return to play protocol (RTP) as described in the NATA position statement on management of concussions. The athlete proceeded through the 4 day RTP with no complications or reoccurrences of signs or symptoms. Eighteen days after initial injury the athlete was cleared by the neurologist and RTP protocol. Uniqueness: Periventricular hemorrhages are an extremely common type of brain bleeds found in pre-term infants. In adults, acute periventricular hemorrhages have

been linked to vicious head injuries such as skull fractures, falling from a height, or accelerated backward falls. However, a search of the literature found no cases of periventricular hemorrhage with an associated athletic concussion. Conclusions: This case highlights the diagnosis of an athlete with a periventricular hemorrhage resulting from a sports-related coup and counter-coup concussion. This case is extremely unique due to no similar documented sport-related cases found through a literature review. This case highlights the need for proper evaluation, recognition of atypical head injuries, referral, and need for individualized plans of care. The athlete made a full return to participation three weeks post injury and has had no further problems or complaints.

Establishing 3-Day And 7-Day Symptom Clusters For Hawaii High School Student Athletes During The First Week Of A Sport-Related Concussion

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Context: Post concussion symptom reports are useful for assessing sport-related concussions. The Post-Concussion Symptom Scale (PCSS) allows clinicians an objective measurement of subjective symptoms. Previous studies have used the 22-item PCSS to group the symptoms into related factor structures; these studies have been limited to specific populations. **Objective**: The purpose of this study was to examine factor structures of high school athletes' symptoms during the acute stage of sport-related concussions. **Design**: A retrospective analysis was conducted using data from the State of Hawaii Department of Education's (DOE) records of Immediate Post-Concussion Assessment and Cognitive Test (ImPACT) from School Years 2010-2012. **Setting**: High school athletes participating in interscholastic athletics were prospectively recruited for the current study. **Participants:** Participants were participating in 11 sports who sustained a concussion were diagnosed, treated, and followed until return to full participation by the high school athletic trainer. Participants where divided into two groups: group one (N=437, males=292, females=145, mean age 15.49 ± 1.33yrs) who were given the PCSS within 3 days (mean days 1.88± 0.91) of injury and group two (N=231, males=139, females=92, mean age 15.55 ± 1.33yrs) who were given the PCSS within 4-7 days (mean days 5.16± 1.31) of injury. **Interventions**: All athletic trainers were required to follow a standardized concussion management protocol including post injury assessment utilizing ImPACT. The PCSS within the ImPACT were extracted. **Main Outcome Measures**: Exploratory Factor Analysis (EFA) was applied to the PCSS of both groups. Factors were extracted using the principal component analysis with orthogonal rotation (Varimax with Kaiser normalization). **Results**: An EFA provided two 4-factor structure models containing cognitive-migraine, emotional, somatic and sleep clusters. The factors explained 57.08% of variance for group one and 66.01% for group two. **Conclusions**: The cognitive-migraine cluster between the two groups differed in symptoms loading. Group one symptoms included headache, vomiting, dizziness, fatigue and difficulty remembering. Group two symptoms included trouble falling asleep, sensitivity to light, difficulty remembering and feeling mentally foggy. The changes in cognitive-migraine cluster during the acute phase of a concussion suggest different accommodations should be considered during 0-3 day and 4-7 days. Identifying how symptom clusters change during the acute phase of a concussion, will allow athletic trainers to make the most beneficial accommodation for athletes during the first week of a sport-related concussion.

The Relationship Between Concussion History And Postural Control Impairments

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Context: Impairments in dynamic postural control are a known consequence of an acute concussion. Some evidence suggests that a history of 3 or more concussions predispose an individual to long term neurological sequela. Objective: The purpose of this study was to investigate impairments in dynamic postural control between individuals following an acute concussion and those with a history of at least three concussions. **Design:** Cross sectional. **Setting:** Biomechanics laboratory. **Patients or Other Participants:** There were a total of 45 participants divided into three groups, 15 participants (8 Female, Age: 20.4+1.6 years, Height: 1.74+0.15m, Weight: 70.6+18.9kg) tested within 24 hours of a concussion (Acute), 15 participants (8 Male, Age: 20.0+1.5 years, Height: 1.78+0.12m, Weight: 83.6+23.0kg) with a history of at least 3 documented concussions (Multiple), and 15 healthy student-athletes (8 Female, Age: 19.9+1.3 years, Height: 1.75+0.09m, Weight: 74.2+10.9kg) who denied a concussion history (Control). Interventions: All participants completed 5 trials of self-paced cued gait initiation (GI). Participants began each trial standing on two forceplates and initiated gait in response to a verbal cue, stepped onto a third forceplate, and continued down a 4.9m walkway. **Main Outcome Measures:** The displacement of the center of pressure (COP), both posterior and lateral, during the anticipatory postural adjustment (APA) phase of GI and the initial step length and velocity were compared between groups with a one-way ANOVA and tukey post-hoc when appropriate. **Results:** There was a significant main effect for all four dependent variables. Post-hoc testing identified a continuum of performance whereby the controls performed best, the multiple group was in the middle, and the acute group performed worst. The posterior COP displacement during the APA was significant between all three groups (6.4+1.1cm, 5.0+1.2cm, and 2.3+1.0 cm respectively, $p<0.001$ for Acute vs Control and Multiple, $p=0.002$ for Control vs Multiple). The lateral COP displacement during the APA was significant between Acute and Control (2.6+1.2 and 6.4+2.2cm, $p<0.001$) and Acute vs Multiple (5.8+1.2cm, $p<0.001$), but not different between Control and Multiple. Step length was only different between Acute and Control (0.57+0.09m and 0.71+ 0.11m, $p<0.001$). Step velocity differed between Control and Acute (0.75+0.13m/s and 0.56+0.09m/s, $p<0.001$) and Control vs Multiple (0.64+0.08m/s, $p=0.021$). **Conclusion:** These results indicate a potential continuum of performance whereby acute concussion demonstrates the greatest impairments in postural control. Individuals with 3 or more concussions demonstrated impairments, compared to healthy controls, in the posterior displacement of the COP and the initial step velocity with their results being similar to what is commonly seen in healthy elderly studies. Recent position and consensus statements agree there is no magic number linking concussions and later-life neurological impairments; however, these results add to the growing body of literature suggesting 3 or more concussions may be a risk factor. This study was funded, in part, by a grant from the National Institute of Health/Neurological Disorders and Stroke: 1R15NS070744–01A1.

The Relationship Between Coping, Neurocognitive Performance, And Concussion Symptoms In High School And Collegiate Athletes

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Context: The inconsistent presentation of concussive symptoms in conjunction with the uncertainty of prognosis (i.e., return to play) can result in a difficult and frustrating time for the injured athlete. Although previous researchers have reported that effective coping efforts are linked to improved outcomes following musculoskeletal sports injuries, the relationship between coping efforts and concussion is unclear. **Objective:** The purpose of the study was to explore the relationship of neurocognitive performance and symptoms to coping responses at 3 and 8 days post-concussion. **Design:** Prospective cohort study **Setting:** This study was performed in a controlled laboratory and field setting. **Patients or Other Participants:** A total of 104 concussed athletes volunteered to participate in the study (73 males: age = 16.26 $\pm$ 2.07 years, mass = 77.2 $\pm$ 16.8 kg, height = 178.4 $\pm$ 8.15 cm, 31 female: age = 16.77 $\pm$ 2.45 years, mass = 62.03 $\pm$ 7.82 kg, height = 166.7 $\pm$ 7.57 cm). **Interventions:** The independent variable in this study was time (baseline, 3, and 8 days post-concussion). Participants completed the Immediate Post-concussion Assessment and Cognitive Test (ImPACT), Post-concussion Symptom Scale (PCSS), and Brief COPE at baseline; and at 3 and 8 days post-concussion. A series of multiple regressions were performed with each of the three coping response factors as the outcome variables and the four

neurocognitive composite scores and total symptoms as predictors. A series of repeated measures (RM) analysis of covariance (ANCOVA) were performed on the Brief COPE subscales and three coping response factors. History of concussion was used as the covariate for all ANCOVAs. **Main Outcome Measures:** Dependent variables included ImPACT composite scores (verbal/ visual memory, reaction time, processing speed), PCSS, and Brief Cope individual and three coping response factors (approach, avoidance, social). RM ANCOVAs with Bonferroni correction and post-hoc means comparisons were performed using Tukey's HSD. Statistical significance was set at apior at $p<0.05$. **Results:** Concussed athletes reported more frequent use of self-distraction (M=3.34±1.49: 3.16±1.56, p=.046), behavioral disengagement (M=2.29 ±.90: 2.14±.51, p=.039), religion (M=2.58±1.38: 2.48±1.27, p= .014), and self-blame (M=2.48±.97: 2.27±.69, p=.001) at 3 days post-concussion compared to 8 days post-concussion. Concussed athletes reported more use of avoidance coping behavior at 3 days than 8 days ($F_{[1, 100]}$ =4.71, p=.032) post-injury. Total symptoms was a significant (p=.001) predictor of avoidance coping at 3 days post-concussion and decreased performance on visual memory was associated with increased avoidance coping (p= .03) at 8 days post-injury. **Conclusion**: Time since injury likely plays a role between neurocognitive performance, symptom reports, and coping. Clinicians should be aware of patients who report higher symptoms early in the course of recovery and have lingering visual memory deficits 1 week post-injury as they may use more potentially maladaptive avoidance coping following concussion.

Gait Stepping Characteristics Are Not Impaired In Individuals With Multiple Concussions

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Context: Recent evidence has suggested that a history of multiple concussions, typically defined as three or more, may result in long-term neurological impairments. The influence of multiple concussions has typically been evaluated using cognitive or neuropsychological testing with limited investigations on postural control in this population. Further, there have been limited examinations on otherwise healthy young adults with a history of multiple concussions. **Objective**: The purpose of this study was to investigate kinematic stepping characteristics in individuals with a self-reported history of three or more concussions. We hypothesized that individuals with a history of multiple concussions would demonstrate a conservative gait strategy evidenced by reductions in gait velocity, step length, and time in single support. **Design**: Cross sectional study. **Setting**: Biomechanics research laboratory. **Patients or Other Participants**: Ten individuals, current or recent student-athletes with a history of at least three self-reported concussions (6M/4F, age: 20.6 ± 1.2 years, height: 1.77 ± 0.12m, weight: 83.8 ± 23.9kg, 3.5 ± 1.0 previous concussions, range: 3 – 6) (Multiple) were closely matched to 10 current student-athletes (6M/4F, age: 20.5 ± 1.6, height: 1.76 ± 0.11m, weight: 83.6 ± 23.0 kg) (Control) of the same sport with no self-reported history of concussion or concussion symptoms; direct or indirect head impacts associated with loss of consciousness, post-traumatic amnesia, or similar. **Interventions**: Both groups performed 10 trials of self-selected paced gait along a 4.9m instrumented walkway. The walkway has been previously established as both valid and reliable. **Main Outcome Measures**: The mean gait velocity, step length, and percentage of the gait cycle in single support were calculated by the instrumented walkway based on footfall kinematics. Dependent variables were compared between groups with one-way ANOVAs. **Results**: There were no between group differences in anthropometric characteristics. There were also no differences between Multiple and Control groups for gait velocity (1.29 ± 0.09m/s and 1.31 ± 0.09m/s, p=0.715), step length (0.67 ± 0.03m and 0.67 ± 0.04m, p=0.982) or the percentage of the gait cycle in single support (38.2 ± 1.0% and 38.3 ± 1.1%, p=0.977). **Conclusion**: The results of this study suggest that a history of at least three concussions does not alter kinematic stepping characteristics during level over ground gait. While recent evidence supports some supraspinal control of gait; level over ground walking is generally considered to be regulated by the central pattern generators located in the spinal cord; thus offering a potential rationale why gait would not be adversely influenced by potential supraspinal impairments. Further, these otherwise healthy young adults may have sufficient compensatory mechanisms to adapt to any potential postural challenges. Future studies should investigate either greater challenges to the postural control systems or additional cognitive dual task challenges.

Gait Variability Following A Sports-Related Concussion

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Context: Impaired postural control is a cardinal post-concussion symptom. Traditional clinical measures of post-concussion postural control are static stances; however, some studies have investigated changes in gait stepping characteristics. Gait variability is potentially a more sensitive measure of postural control and has successfully identified impairments in populations with central neuro-physiological disorders. **Objective**: The purpose of this study was to examine gait variability following a concussion. We hypothesized that those with concussions would demonstrate increased gait variability compared to healthy subjects. **Design**: Prospective longitudinal. **Setting**: Biomechanics laboratory. **Participants**: Ten participants (6 Female, age: 18.9 $\pm$ 1.1 years old, height: 1.75 $\pm$ 0.05m, weight: 77.7 $\pm$ 18.8kg; 10% LOC rate, 40% PTA rate, all Grade II concussions on the Cantu revised grading scale) who suffered sports-related concussions during intercollegiate athletic participation were matched to ten healthy control participants based on gender and height. **Interventions**: Both groups performed 10 trials of self-selected paced gait along a 4.9m instrumented walkway. The walkway has been previously established as both valid and reliable. The concussion participants baseline testing was performed during pre-participation physicals prior to participation in intercollegiate athletics and their second testing session was within 24 hours of suffering a sports-related concussion. The control participants were tested on two separate occasions. **Main Outcome Measures**: The dependent variables of interest included step length variability, step width variability, and step time variability. These variables were expressed using a coefficient of variation which is (standard deviation/mean) *100. Dependent variables of interest were compared with three 2x2 (group x day) repeated measures ANOVAs. **Results**: There was no group by time interaction (p=0.964, p=0.779) or main effects for time (p=0.757, p=0.226) for step length gait variability (Concussion baseline: 2.65 $\pm$ 0.29, post-injury: 2.94 $\pm$ 0.67; Control baseline: 2.68 $\pm$ 0.57, day 1: 2.98 $\pm$ 0.37) or step width variability (Concussion baseline: 3.08 $\pm$ 0.67, post-injury: 3.17 $\pm$ 0.69; Control baseline: 2.32 $\pm$ 0.71, day 1: 2.51 $\pm$ 0.37). There was no interaction (p=0.824), but there was a main effect for time (p=0.004) for step time variability (Concussion baseline: 2.65 $\pm$ 0.29, post-injury: 2.94 $\pm$ 0.67; Control baseline: 2.68 $\pm$ 0.57, day 1: 2.98 $\pm$ 0.37). **Conclusions**: The results of this study suggest that athletes suffering from sports-related concussion do not display altered gait variability compared to healthy controls. This is surprising as previous studies have identified differences in stepping characteristics and center of mass sway, suggesting a conservative gait strategy had been adopted. Potentially, these results indicate that otherwise healthy post-concussion student-athletes have sufficient compensatory mechanisms and/or strategies to reduce gait variability. Reductions in postural variability have previously been hypothesized in static postural stability studies which utilized approximate entropy measures. This study was funded, in part, by a grant from the National Institute of Health/ Neurological Disorders and Stroke: 1 R 1 5 N S 0 7 0 7 4 4 – 0 1 A 1 .

Health-Related Quality Of Life In Pediatric Patients Following Mild Traumatic Brain Injury: A Systematic Review

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Context: Pediatric patients are commonly affected by mild traumatic brain injury (mTBI), with approximately 475,000 children under the age of 14 suffering from mTBI annually. Studies in adults have reported that mTBI causes a wide variety of changes in health-related quality of life (HRQoL), including emotional status, neurobehavioral disturbances, and cognitive impairments. However, it is unclear whether the same HRQoL deficits occur in younger patients and whether any deficits are consistent across studies among the pediatric population. **Objective:** To systematically evaluate the evidence regarding HRQoL in pediatric patients following mTBI. We hypothesized that following mTBI pediatric patients would demonstrate decreased HRQoL, specifically in physical, psychosocial, and social domains. **Data Sources:** A systematic search of computerized bibliographic databases was performed using PubMed, CINAHL, ERIC, and OVID. **Study Selection:** Studies were included if they focused on human subjects, pediatric mTBI patients, measured HRQoL or related components of HRQoL, included a full abstract, and were peer reviewed. Keywords used in the search included mTBI, concussion, pediatric, child, adolescent, HRQoL, quality of life, emotional, psychosocial, social, cognitive, school, and physical. Search terms were combined with the AND Boolean term. The link-out feature of PubMed was used to search for related articles and a hand search of references from retrieved articles was performed. **Data Extraction:** Each study was

independently evaluated by two investigators using the STROBE Checklist and articles were assessed for relevance, completeness of information, and methodological quality. Data extracted included the number of patients, age, length of time post-mTBI, outcomes instrument used, subscales of outcomes instrument, inclusion of a control group, and HRQoL outcomes. **Data Synthesis:** 582 studies were found with 33 studies relevant to the inclusion criteria and included in the review. These studies used 88 different outcomes instruments. Four studies evaluated symptoms and found headache as the most commonly reported symptom. Two studies evaluated sleep-related HRQoL, with sleep problems occurring more often in the first 6 months following injury. Behavior was evaluated in 20 studies, with 5 studies reporting worsening behavior in mTBI patients and the other 15 finding no differences in behavior when compared to a control group. Studies evaluating interactions with family and friends reported no issues with reintegration into these social environments. **Conclusions:** Results indicate that mTBI may impact HRQoL in pediatric patients, with lingering symptoms and behavioral problems most commonly reported. However, the variety of outcomes measures used, varied age groups assessed, and inconsistent follow-up time points make it difficult to determine the exact nature and extent of HRQoL deficits in this population. Future studies are needed to evaluate the most meaningful of current outcome tools and to recommend a specific tool that should be used when evaluating the HRQoL of concussed adolescents.

The Effects Of Cognitive Fatigue On Balance In A Moderately Active Population

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Context: Balance is an integral part of activity and plays a key role in injury prevention. Because student-athletes are expected to meet certain academic standards while also excelling in their respective sports, it is necessary to determine if they are at greater risk for balance disturbances due to cognitive fatigue. **Objective:** To discover the relationship between cognitive fatigue and balance. **Design:** Randomized Controlled Trial with Crossover Study Design. **Setting:** University Laboratory. **Patients or Other Participants:** Eighteen healthy, college-aged students (5 men, 13 women; age = 20.94 ± 2.07 years; height = 170.60 ± 11.17 cm; mass = 63.84 ± 11.85 kg). **Interventions:** Cognitive fatigue and measures of balance were assessed before and after both a cognitive fatigue task and control task completed two to four days apart. The cognitive fatigue task consisted of two hours of the Paced Auditory Serial Addition Test (PASAT), and the control task consisted of watching a two-hour PBS documentary on train travel. **Main Outcome Measures:** A 2 (treatment groups) x 2 (time: pretest, posttest) repeated measures ANOVA was used to determine if there were any differences between all pre-task and post-task balance assessments and cognitive fatigue surveys. Measures of balance data were collected on the NeuroCom Smart Equitest System® using the Limits of Stability Test (LOS) and Sensory Organization Test (SOT). Cognitive fatigue was assessed using the Fatigue Assessment Scale (10 questions) and the Multidimensional Fatigue Symptom Inventory-Short Form (30 questions). The three trials of each condition of the SOT were averaged together to create one score for each of the six conditions. Reaction time, movement velocity, and directional control from the LOS, the averages of the six conditions of the SOT, and the cognitive fatigue surveys were measured and compared. **Results:** A significant difference was found between control and cognitive fatigue conditions in the LOS test measurement for reaction time in condition three; right forward (pre-control: .69 ± .15 s; post-control: .78 ± .23 s; pre-fatigue: .8 ± .25 s; post-fatigue: .94 ± .32 s; p = .033) and in the LOS test measurement for movement velocity in condition two; right forward diagonal (pre control: 7.83 ± 1.67 m/s; post-control: 7.34 ± 2.37 m/s; pre-fatigue: 6.71 ± 2.54 m/s; post-fatigue: 5.79 ± 2.21 m/s; p = .044). There were no significant differences found between conditions for the SOT (p e•.05). All questions of the cognitive fatigue survey were analyzed and 13 had significant differences between conditions indicating increased cognitive fatigue (p d•.05). **Conclusions:** Reduction in static balance performance on certain measurements was demonstrated with cognitive fatigue. Further research is needed to determine if cognitive fatigue has an affect on dynamic balance or balance in other populations such as highly trained athletes.

Examining Morphological Changes Of The Anterior Talofibular Ligament In A Female Collegiate Volleyball Player Following A Severe Lateral Ankle Sprain

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Background: This case involves a 20 year-old female collegiate volleyball player withno prior history of an ankle sprain. The athlete jumped up at the net to block a spike,landed on the foot of the opposing player, and collapsed to the ground. She complainedof pain (8/10), immediate swelling, and needed to be assisted off the court. Uponinspection, the athletic trainer determined a positive anterior drawer and talar tilt test.Range of motion and strength test were not conducted due to pain. **Differential Diagnosis:** Anterior talofibular ligament (ATFL) sprain, calcaneofibular ligament sprain,distal tibia-fibula fracture, high ankle sprain, metatarsal sprain. **Treatment:** The athlete'sankle was immediately iced, wrapped, and elevated. The athlete's ankle was tapedovernight with a horseshoe and given a walking boot and crutches with an initial noweight bearing status. Due to the severity of the swelling and ecchymosis, an MRI wasordered, revealing a complete tear of the ATFL, sprained calcaneofibular ligament, bonebruise on the medial neck of talus, strain of peroneus longus, and a small split tear ofthe peroneus brevis. Twelve days post-injury, the athlete was transitioned from thewalking boot to an Aircast. Twenty days post-injury, the athlete was transitioned out ofthe Aircast to full weight bearing status. The athlete was released to jog 1 month postinjury. The athlete sought out a foot and ankle specialist and was instructed to reduce activity to allow more time for healing. The athlete returned to sport-specific activities 3 months post-injury. With continuing rehabilitation and taping of the ankle, the athlete has returned to full participation but still complains of pain, instability, and weakness. **Uniqueness:** Musculoskeletal ultrasound (MSUS) images of the athlete's ATFL were obtained pre and post injury. During preseason screening, a MSUS image was acquired prior to injury. After the injury, MSUS images were taken 6 days, 1 month, 3 months, and 7 months post-injury. These images were used to track the healing process of the ligament after a complete tear to the ATFL. Prior to injury, the MSUS image of the ATFL showed a clean, paralleled fibrous nature of the ligament. The MSUS image 6 days post-injury revealed large pockets of edema around the ankle joint and a detached ATFL. The MSUS image 1 month post-injury still presented with edema in the area and a detached ATFL, though parts of the ATFL can now be seen in the image. The MSUS image 3 months post-injury displayed the form of the ATFL but a gap within the ligament indicated that complete healing had not occurred yet. Despite the expected healing time of the ATFL, the MSUS image 7 months post-injury still exhibited abnormalities in the ligament. **Conclusions:** Though the injury presented in this clinical case doesn't involve a unique injury, the distinctive nature of this study involves visual images of the healing process of the ATFL through ultrasound imaging techniques. Since MRI's are expensive with particular contraindications, they are not normally ordered for ankle sprains. MSUS, which is much safer and cost-effective, can provide quality images that can identify a torn ATFL. One of the roles of an athletic trainer is to return the athlete back to sport as efficiently as possible. In this case, even with 3 months of rest from sport-specific activities, the athlete still currently complains of substantial residual symptoms. In severe ankle sprains such as this case, understanding the healing process of the ligaments of the ankle through MSUS may assist in the progression of rehabilitation to prevent further damage or residual symptoms that may occur after the initial injury.

Relationship Between Weight Bearing Lunge And Non-Weight Bearing Dorsiflexion Range Of Motion Measures

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Context: The weight bearing lunge (WBL) is a reliable method of assessing dorsiflexion range of motion (ROM) in a more functional position than traditional open kinetic chain methods. While the WBL is more functional, little research has been conducted to determine the relationship between the WBL and the long-sit (LS) or short-sit (SS) measures of dorsiflexion ROM. **Objective:** To determine the relationship between WBL and non-weight bearing SS and LS dorsiflexion ROM measures while establishing normative values for the WBL measure in a young adult population. **Design:** Descriptive cohort study. **Setting:** Research laboratory. **Patients or Other Participants:** 107 healthy college-aged participants (57 females, 50 males; 20.52±1.92 years; 172.10±1.46 cm; 72.52±15.99 kg) free of current ankle or lower extremity injuries volunteered for this study. **Interventions:** An experienced examiner performed the assessment on each participant in a single session. Dorsiflexion ROM was measured in two different positions (LS and SS) with a long axis goniometer. For both measures, the examiner placed the participant in 90° of dorsiflexion with the goniometer fulcrum on the lateral malleolus and aligned the arms with the fibular head and parallel to the 5th metatarsal. The WBL was assessed by asking the participant to stand facing a wall with the great toe on a tape measure six inches from the wall. Participants then lunged forward in an attempt to touch the anterior aspect of their knee to the wall while keeping their heel in full contact with the ground. Participants continued to move their foot away from the wall until they could no longer maintain contact with the anterior knee or the heel. Once the maximal distance (cm) was obtained, a measure of distance from the wall was collected. Measures were taken bilaterally on all participants and all ROM measures were counterbalanced to improve internal validity. **Main Outcome Measures:** Pearson correlation coefficient (*r*) (d".05) was used to determine the relationship between measures. Means and standard deviations were used to report normative data. **Results:** A moderate positive correlation was shown between the WBL and LS on both the right (*r*=.671,P<.001) and left (*r*=.643,P<.001) limbs. The SS and WBL measures also demonstrated a moderate positive correlation for the right (*r*=.722,P<.001) and left (*r*=.690,P<.001) limbs. WBL mean values reported for males (right =10.91±4.10 cm, left=11.10±4.31 cm) and females (right=11.35±2.89 cm, left=11.40±3.6 cm). **Conclusions:** While the WBL has gained popularity, the relationship between the WBL and the goniometric measures of ROM are not strong enough to use these methods interchangeably. The WBL could be used to assess a patients' functional dorsiflexion ROM more effectively unless weight bearing is contra-indicated. Normative values for the WBL can be used as a reference for clinicians as they implement the WBL with a collegiate population.

Weight-Bearing Dorsiflexion Restrictions Are Present On The Self-Reported Worse Limb In Those With Chronic Ankle Instability

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Context: Chronic ankle instability (CAI) is a self-reported condition in which those who sustain an ankle sprain go on to have residual symptoms and episodes of giving way. One of the potential contributing factors to CAI is a dorsiflexion range of motion (DFROM) restriction. It is currently unclear whether DFROM restrictions contribute to self-reported functional limitations associated with CAI. **Objective:** To determine whether dorsiflexion is reduced in the self-reported worse limb relative to the self-reported better limb in subjects with CAI. **Design:** Cross-sectional study. **Setting:** Laboratory. **Participants:** 41 participants with self-reported CAI (18 males, 23 females; age: 23.7±5.1 yrs; height: 1.7±0.9 m; mass: 75.9±15.4 kg) participated. All subjects had a history of at least 1 ankle sprain with current symptoms of CAI on at least 1 side including recurrent episodes of giving way at the ankle. **Interventions:** Each participant self-identified which ankle was considered to be the more functionally limited by using the Ankle Instability Instrument (AII). A score of e"5 on the AII was considered as an ankle with CAI. All subjects also completed the Foot and Ankle Ability Measure (FAAM) Activities of Daily Living (ADL) and FAAM Sport scales for the right and left ankles. These scales provide information about a participant's perception of disability, associated with ADL and sport activities respectively within the past week due to their ankle instability. The weight-bearing lunge test (WBLT) was

used to measure DFROM. Subjects performed 3 trials of the WBLT in which they kept their test heel firmly planted on the floor while they flexed their knee to the wall. Maximum dorsiflexion was defined as the distance from the great toe to the wall based on the furthest distance the foot was able to be placed without the heel lifting. **Main Outcome Measures:** The independent variable was side (self-reported worse vs. self-reported better). The dependent variables were the FAAM-ADL (%), FAAM-Sport (%), and the mean WBLT distance (cm). Paired t-tests were used to compare the dependent variables between sides. Alpha was set a priori at $p<0.05$. **Results:** The self-reported worse ankles had higher AII scores (6.7±1.2) compared to the self-reported better ankles (2.9±2.75, $p<0.001$). There were significant deficits in the FAAM-ADL and FAAM-Sport when comparing the self-reported worse (FAAM-ADL: 80.0±11.7%; FAAM-Sport: 64.9± 13.3%) to the self-reported better side (FAAM-ADL: 93.4±11.2%, $p<0.001$; FAAM-Sport: 86.7±17.5%, $p<0.001$). The self-reported worse ankle (9.2±3.9 cm) also had significant DFROM deficits compared to the self-reported better ankle (10.9±4.03 cm, $p=0.002$). **Conclusion:** Significant functional limitations associated with ADL and sport activities on the self-reported worse side were found in conjunction with significant DFROM deficits on the worse side. These findings indicate that DFROM restrictions potentially contribute to functional limitations in ADL and sport activities in those with CAI.

Subjects With Chronic Ankle Instability Present With Altered Proximal Kinematics During Shod Gait On A Treadmill

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Context: Ankle kinematic differences have been found between individuals with chronic ankle instability (CAI) compared to healthy controls. However, there is limited research comparing more proximal joint kinematics. Because distal kinematic differences between groups have been identified, it is important to evaluate kinematics up the kinetic change to potentially elucidate adaptations made by individuals with CAI. **Objective:** To determine if there are knee or hip kinematic differences, in the sagittal and frontal planes, in subjects with CAI compared to controls while walking and jogging on a treadmill in shoes. **Design:** Descriptive laboratory study **Setting:** Motion analysis laboratory **Patient or Participants:** Twenty-seven subjects with self-reported CAI (9 males, 18 females; age = 24.56 ±5.37 years; mass = 71.44±11.93kgs; height = 170.93±8.37m; Foot and Ankle Ability (FAAM) score = 89.8±8.1; FAAM-Sport score = 73.1±12.9; number of previous sprains = 4.89±3.20), and 27 healthy controls (11 males, 16 females; age = 22.56 ±3.49 years; mass = 65.80±13.72kgs; height = 167.51±15.44m; FAAM score = 100.0±0.0; FAAM-Sport score = 100.0±0.0) participated. . **Interventions:** Subjects walked (speed =1.34 m/s) and jogged (speed=2.68 m/s) on a treadmill with embedded force plates while a 12-camera motion analysis system captured 3-D lower extremity kinematics. One 15-second period of gait (average walking strides=10; average jogging strides=20) was captured at each speed for analysis. Each stride of the gait cycle was normalized to 100 increments. Sagittal and frontal plane knee and hip angles were calculated at each increment. Group means and associated 90% confidence intervals (CIs) were calculated in each plane across the entire gait cycle. To identify significant differences, increments where the CI bands for the two groups did not cross each other were identified. Mean differences and standard deviations were calculated for increments in which the CI bands did not cross. **Main Outcome Measures:** Sagittal and frontal kinematics at the knee and hip were measured throughout the entire gait cycle. **Results:** During shod walking, individuals with CAI presented with less knee flexion compared to healthy controls (mean difference = 3.32±0.06°) from mid-stance to toe off (49-54% of gait cycle).While jogging, the CAI group presented with more hip flexion (mean difference = 6.34±0.27°) from loading to toe off (12-34% of gait cycle) and more knee flexion than controls (mean difference 7.52±1.36°) during swing (77-91% of gait cycle). No frontal plane differences were noted at either joint at either speed. **Conclusions:** Proximal kinematic alterations from mid-stance to toe off as well as during swing varied between individuals with and without CAI. These changes may help explain the perceptions of instability and the recurrent sprains that occur in individuals with CAI.

Balance Training Changes Center Of Pressure Location During Unipedal Standing In Subjects With Chronic Ankle Instability

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Context: Individuals with chronic ankle instability (CAI) demonstrate altered postural control and utilize a more anterolateral center of pressure (COP) location during unipedal quiet standing compared to healthy individuals. Postural control can be improved after balance training, but the mechanism of this improvement is unknown. Changes in the spatial location of COP location following balance training are a potential mechanism of improved postural control. **Objective:** To determine if a 4-week balance training program changes the location of COP during unipedal stance in subjects with CAI. **Design:** Randomized control trial. **Setting:** Laboratory. **Patients or Other Participants:** 31 individuals with self-reported CAI were randomly assigned to a balance training group (6 males, 10 females; age=22.2±4.5 years; height=168.9±7.7cm; mass= 63.0±8.1kg; previous sprains = 6.3±7.1; Foot and Ankle Disability (FADI)=85.5 ± 8.4%; FADI-Sport= 69.9±12.1%) or a control group (6 males, 9 females; age=19.6±1.3 years; height=173.3±9.8cm; mass=67.7±13.7 kg; previous sprains=4.6± 2.5; FADI=82.9 ± 7.4%; FADI-Sport=66.5±9.8%). **Interventions:** The balance training group performed a 4-week supervised balance program that was progressed in an individualized manner. Exercises included static and dynamic single limb balancing tasks. The control group did not perform any balance training and was asked to maintain their normal activity levels across the study period. **Main Outcome Measures:** All subjects performed three successful 10-second single limb balancing trials on a force plate with eyes open and closed before and following the 4 week intervention. COP data was collected at 50 Hz resulting in 500 data points in each trial. Each subject's foot was modeled as a rectangle into four quadrants. Additionally, the foot was also divided into anterior and posterior halves and medial and lateral halves. The frequency of COP data point location in each region was recorded across the length of each trial and served as the dependent variable. The independent variables were group (balance training, control) and time (pre, post). For each region, separate 2x2 ANOVAS with repeated measures were computed for eyes open and eyes closed data. Alpha was set a priori at $p<0.05$. **Results:** Changes in COP location following balance training were seen in the anterior-posterior direction, but not in the medial-lateral direction. After the intervention, COP location in the balance training group shifted from a more anterior to less anterior in both eyes open (pre=319.1±165.4, post= 160.5± 149.5; p=.004) and eyes closed trials (pre=387.9±123.8, post= 189.4± 102.9; p<.001) while the non-balance training group did not shift substantially in the eyes open (pre=214.1±193.3, post=230.0±176.3) or eyes closed trials (pre=326.9±134.3, post= 338.2±126.1). **Conclusions:** The balance training program resulted in a COP location shifted from a more anterolateral position to a more posterolateral one which more closely resembles healthy subjects. This may be due to behavioral changes as a result of a more optimally functioning and less constrained sensorimotor system.

Preparatory Movement Patterns During A Laboratory Recorded Ankle Sprain

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Context: Establishing the injury mechanisms of recurrent ankle sprains is a critical step in developing preventative interventions. In the research laboratory, it is unethical to produce an injury for the examination of biomechanics during a real recurrent ankle sprain. However, we observed an accidental acute ankle sprain in a participant with chronic ankle instability (CAI) during biomechanical testing in an ongoing research study. Altered feed-forward sensorimotor control has been suggested as a consequence of CAI. A more definitive description of feed-forward movement patterns of an actual ankle sprain case would improve the understanding of recurrent ankle injury mechanisms and may contribute to the development of prevention strategies for recurrent ankle sprains. **Objective:** Present preparatory movement patterns of an acute ankle sprain during a stop-jump task. **Design:** Single-subject descriptive laboratory. **Setting:** Research laboratory. **Patients or Other Participants:** A recreationally active male (180.34cm, 79.45kg, 20yrs) with unilateral CAI [Foot and Ankle Disability Index (FADI)=28.85%, FADI sports=15.63%] volunteered for an IRB-approved case-control study investigating the effect of CAI on the location of center of mass (COM) during a bilateral stop-jump task. **Interventions:** The participant experienced a mild recurrent right ankle sprain during the third of five trials of the stop-jump task. Kinematics and kinetics were recorded with a motion capture system interfaced with two force platforms. **Main Outcomes:** The location of COM and sagittal-and frontal-plane

kinematics for the knee and ankle joint were calculated during a preparatory phase that was defined as the time interval of 200ms before initial contact with the force platforms. The injury trial was compared with the ensemble average of the two non-injury trials performed by this participant. Due to the nature of the observed data from a single trial from a single participant, data are presented without statistical comparisons. **Results:** During the injury trial, there was greater average ankle plantar flexion (18.1°), ankle inversion (9.4°), and knee adduction (4.1°), as well as less knee flexion (22.9°) during the 200ms preparatory phase compared to mean values from the 200ms preparatory phase of the ensemble curves of the two non-injury trials (plantar flexion=7.5°, inversion=0.01°, knee adduction= 1.1°, knee flexion=25.5°). In the injury trial, COM was located 2cm higher (1.35m) and shifted 4 cm more contralaterally (0.61m) toward the non-involved side during the preparatory phase compared to the non-injury trials (height=1.33m, side=0.57m). **Conclusion:** We observed differences in preparatory movement patterns at the knee and ankle during a trial in which a recurrent ankle injury occurred. These data may contribute to understanding the injury mechanisms of recurrent ankle sprains and provide an insight into how to develop more effective preventative interventions for recurrent ankle sprains.

Functional Performance Tests In A Recreationally Active Population With Chronic Ankle Instability And A Healthy Control Group

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Context: Functional performance deficits may be present in a population with chronic ankle instability (CAI). However, few clinical tools have been able to differentiate between performance ability in a CAI and uninjured population. **Objective:** To determine if there are differences in functional performance between a CAI and control group in a recreationally active population. **Design:** Cross-sectional. **Setting:** Biomechanics Laboratory. **Patients or Other Participants:** Fifty volunteers were divided into two groups of 25 each. The CAI group (6 male, 19 female; age=20.60 ± 1.47yrs; height=166.22 ± 8.52cm; mass=67.33 ± 11.93kg) had at least 1 moderate-severe ankle sprain, 2 episodes of giving way at the ankle and a Cumberland Ankle Instability Tool (CAIT) score d”26 indicating poor function. The control group (11 Male, 14 female; age=20.16 ± 1.25yrs; height=167.47 ± 8.94cm; mass=65.22 ± 11.67kg) had no history of ankle injury and a CAIT score e”28 indicating good function. **Interventions:** In a single testing session participants completed the CAIT questionnaire and performed the Star Excursion Balance Test (SEBT) in the posteromedial direction, Single Leg Hop Test (SLHT), and Time in Balance Test (TIB) in a randomized order. The SLHT and TIB were videotaped. After testing, a single rater, with reliability > 0.80, watched the video and recorded the time to complete SLHT and the length of time the participant maintained the testing position for TIB. Independent sample T-tests were performed with ˜<0.05. **Main Outcome Measures:** CAIT scores were calculated for the test limb. The average SEBT reach distance of 3 trials was normalized to % leg length, with higher % indicating better function. Both SLHT and TIB were reported as time in seconds, and the average of 2 trials and 3 trials, respectively, were calculated. Shorter times indicated better performance. Group means were compared via independent samples T-tests. **Results:** The CAI group had CAIT scores of 20.84 ± 4.45, while the control group had 29.72 ± 0.54. SEBT reach distance was significantly different between control (93.67 ± 10.15%) and CAI groups (85.30 ± 7.54%) (p=0.002). SLHT was also significantly different between control (15.32 ± 5.01sec) and CAI groups (18.64 ± 5.57sec) (p=0.031). TIB was not significantly different between control (44.46 ± 14.42sec) and CAI groups (41.02 ± 14.22sec) (p=0.40). **Conclusions:** These results suggest that participants with greater perceived instability in their ankle (lower CAIT scores) also tended to exhibit performance deficits on the SEBT and SLHT when compared to healthy controls. Conversely, there was no significant difference between groups on TIB. The SEBT and SLHT may provide clinicians cost and time-effective clinical tools for screening and rehabilitation purposes.

Plantar Cutaneous Sensory Deficits Are Present In Those With Chronic Ankle Instability

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Context: Sensory deficits have been identified on the plantar aspect of the foot in individuals with chronic ankle instability (CAI). While these deficits have been identified using custom-designed laboratory instruments, it is unclear if plantar cutaneous somatosensory alterations can be detected using common clinical techniques for assessing sensation such as Semmes-Weinstein Monofilaments (SWM) in these individuals. Objective: To compare plantar cutaneous detection thresholds between individuals with and without CAI using SWM. Design: Case-control study. Setting: Laboratory. **Patients or Other** Participants: Ten participants with CAI (2 males, 8 females, age=22.4±2.7 years, height=171.6±10.1cm, mass=71.4±13.2kg, Foot and Ankle Ability Measure-Sport=75.93±19.6%) were gender and side matched to ten healthy participants (age=22.4±1.7 years, height=166.9±9.3cm, mass=65.9±13.6kg, Foot and Ankle Ability Measure-Sport=100.0±0.0%). Participants in the CAI group reported at least one ankle sprain, two episodes of giving way in the past three months, and answered "yes" to at least five items on the Ankle Instability Instrument. Interventions: Each participant reported to the laboratory on a single occasion. Three sites on the foot sole were assessed in a counterbalanced order including the head of the first metatarsal (1st-met), the base of the fifth metatarsal (5th-met), and the center of the heel. Cutaneous sensation of the foot sole was assessed using a 20-pen SWM kit. SWM were applied perpendicular to the skin, pressed until the monofilament formed a 'C' shape, and held in place for 1-2 seconds. Based on the perceptual response of the participant, a heavier or lighter weight SWM was presented for the subsequent stimulus. An adapted staircase algorithm was used to determine the lightest weight SWM which could be identified, representing the detection threshold. SWM detection thresholds are reported as an index value ranging from 1.65-6.65. Main Outcome Measures: The dependent variables were the SWM detection threshold at each site (1st-met, 5th-met, and heel), while the independent variable was group (CAI, healthy). Detection thresholds associated with greater SWM weights represented lesser sensitivity, while lower SWM weights represented greater sensitivity. Separate Mann-Whitney U tests were used to examine group differences for each site. Descriptive statistics were reported as mean±standard deviation. Alpha level was set a priori at $p<0.05$ for all analyses. Results: Significant differences were identified between groups for detection thresholds at the1st-met (CAI=4.19±0.44, Healthy =3.57±0.46; $p=0.01$), the 5th-met (CAI=4.31±0.26, Healthy= 3.73± 0.40; $p<0.001$), and the heel (CAI=4.52±0.30, Healthy=4.10±0.27; $p=0.009$). Conclusions: The main finding of this study is that those with CAI have decreased cutaneous sensation at the1st-met, 5th-met and heel compared to healthy individuals when examined with clinical measures of sensation. These somatosensory deficits may be related to sensorimotor alterations demonstrated by those with CAI such as deviations in gait and postural control. Plantar cutaneous sensation should be a consideration in the rehabilitation strategy for patients with CAI.

Does Previous History Of Ankle Sprain Alter Muscle Strength And Hip Kinematics During A Jump-Landing Task In An Adolescent Population

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Context: Ankle sprains are among the most common injuries sustained in an active population. Previous research has identified an association between previous history of an ankle sprain and hip abductor weakness. It is not known if this weakness affects movement patterns in adolescents with a history of ankle sprain. **Objective**: To identify if differences in hip kinematics during a jump-landing task and hip muscular strength are present in adolescents with a history of ankle sprain and their non-injured peers. **Design**: Cohort study **Setting**: High School Setting **Patients or Other Participants:** 61 healthy, active local high school students (32 males, 29 females, Age: 15.98±1.35years; Mass: 63.45± 11.77kg; Height: 170.52±10.0cm) were placed in either the uninjured (UNI) group (n=48) or injured (INJ) group (n=13) based on previous history of an ankle sprain. **Interventions**: Subject's isometric strength of the hip musculature was assessed using a handheld dynamotor. Each strength test utilized two trials and all strength data were normalized to body mass. Subjects completed three trials of a jump-landing task where they were asked to jump forward from a 30-cm high box a distance of half their body height. The trials were recorded using an electromagnetic motion analysis system. **Main Outcome Measures:** Normalized peak isometric strength of the hip extensors, hip abductors, hip internal rotators, and hip external rotators were measured. Three-dimensional hip kinematics at initial ground contact and peak angles (normalized to

bodyweight and height) were calculated using the average of the three trials. Independent t-tests were used to compare kinematic and hip strength measurements between the UNI and INJ groups (d".05) **Results:** The only significant difference between INJ and UNI hip kinematics was hip adduction at initial contact (p=. 049; INJ= -18.73±7.24; UNI= -13.95±7.71). This indicates that INJ landed in significantly more hip abduction at initial contact than UNI. Although it was not significant there was a trend for INJ to have higher peak hip adduction (p=.051; INJ= -9.21± 8.98; UNI=-3.94±8.24) indicating that INJ go through more hip abduction throughout the jump-landing task. There were no other significant differences found for hip strength measurements of the UNI and INJ groups. **Conclusions:** Although we did not find a significant difference in hip abductor strength it is still important to note that a difference was observed in the movement pattern of adolescents with a history of an ankle sprain. Further research should be conducted to identify potential contributing factors to this change in movement pattern. As a result, clinicians should assess and address any changes in frontal plane hip motion when treating patients with ankle sprains.

Noise-Enhanced Center Of Pressure Complexity In Individuals With Chronic Ankle Instability

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Context: Chronic Ankle Instability (CAI) has been shown to impair balance in single-leg, but not double-leg, quiet stance. However, nonlinear measures of center-of-pressure (CoP) signal complexity may be sensitive for detecting bipedal impairments. Furthermore, if bipedal balance deficits exist, then a therapy such as stochastic resonance stimulation (SRS) may enhance balance by making postural control less constrained. **Objective:** (1) Examine CoP complexity to determine if CAI influences balance in double-leg quiet stance (group effect) and (2) determine whether SRS influences CoP complexity in CAI subjects (condition effect). **Design:** A cross-over design with two groups (CAI and No CAI) and two treatments (SRS_{on}, SRS_{off}). **Setting:** Research Laboratory. **Patients or Other Participants:** Fifteen subjects presenting with CAI (171.7±8.2 cm, 66.5±10.5 kg, 22.7±2.6 yrs) and fifteen healthy subjects without CAI (169.6±7.7 cm, 63.8±11.1 kg, 23.1±3.8 yrs). Inclusion criteria for the CAI group included feelings of "giving way" at the ankle (0.57±0.54 "give-ways" per week) and repeated sprains during activity (3.2±2.5 sprains per subject). **Interventions:** Quiet double leg stance trials without vision or shoes were collected on a force plate at 50 Hz for 20 seconds in a control condition (SRS_{off}) and an optimal SRS intensity condition (SRS_{on}). The SRS signal was applied through vibrating tactors placed on the skin over the peroneus longus, anterior and posterior tibialis, and gastrocnemius muscles of the leg with CAI or a matched test leg. Testing order was a block randomized design. **Main Outcome Measures:** Sample Entropy (SampEn) of the Anterior/Posterior (AP) and Medial/Lateral (ML) COP displacement time series (unitless). Lower values indicate more constrained balance. Planned comparisons were performed with one-tailed independent t-tests for: (1) group differences during SRS_{off} and (2) CAI SRS_{on} versus No CAI SRS_{off} (alpha level=0.05). **Results:** During SRS_{off}, AP SampEn was significantly lower in the CAI group (CAI=0.51±0.08, No CAI group 0.58±0.09; $t_{(28)}$=-2.09, P=0.02). AP SampEn (0.53±0.13) in the CAI group during the SRS_{on} condition was not different than AP SampEn of the No CAI group during the SRS_{off} condition ($t_{(28)}$=1.21, P=0.12). No significant differences were observed in the planned comparisons for the ML SampEn data (P>0.05). **Conclusions:** The present findings suggest that SampEn may be used to identify differences in bipedal CoP complexity between CAI and No CAI groups. Lower SampEn values in the CAI group indicate a loss of complexity and suggest that postural control in this group is overly constrained and less adaptive. CoP dynamics in the CAI group during SRS_{on} were no different than in the No CAI group during SRS_{off}, which may reflect the relaxation of system constraints with SRS treatment. Future research should be directed at identifying these constraints and the mechanisms by which SRS may reduce them.

Ankle Copers Demonstrate Altered Muscle Activation Strategies For Maintaining Joint Stiffness

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Context: The prevention of ligamentous injury is dependent on the ability to regulate joint stiffness by preparing for and responding to potentially harmful loads. While studies have identified changes in joint stiffness and laxity in patients with recurrent instability versus those without symptoms (copers); no studies have investigated neuromuscular factors that may regulate joint stiffness among this subset of patients. **Objective:** To investigate muscle activation strategies from the lower leg during an ankle perturbation between patients with ankle instability, healthy controls, and copers. **Design:** Post-test only with control group. **Setting:** Biomechanics laboratory. **Patients or Other Participants:** Fifty-eight subjects (22.6±3.3yrs; 171.0±9.7cm; 71.8±18.0kg) were stratified using the Cumberland Ankle Instability Tool into healthy control (CON, n=19), functionally unstable (UNS, n=19), and coper (COP, n=20) groups. **Interventions:** Subjects were tested on a custom-built stiffness device with the hip and knee flexed and the ankle secured to a foot plate. Surface electromyography (EMG) was collected from tibialis anterior (TA), peroneus longus (PL), and soleus (SOL) muscles. After collecting maximal voluntary contractions (MVC) for all muscles, subjects were asked to pronate the ankle (30% effort) as a rapid inversion (20°) perturbation was applied to the joint at a random point. Subjects were instructed to hold the contraction through the perturbation. Joint position and EMG activity were collected in custom software at 2400Hz. **Main Outcome Measures:** Mean EMG (%MVC) was calculated for 250ms prior to (PRE), 250ms following (POST-1), and 250-500ms following (POST-2) the perturbation. Differences between groups were tested with a repeated-measures ANOVA with 2 within-subjects factors (Time, 3 levels; Muscle, 3 levels) and 1 between-subject factor (Group, 3 levels). **Results:** A significant Time by Group interaction effect ($F_{4,94}=3.78$, $p=0.007$) was observed. No other group effect was significant. Pairwise comparisons revealed the pooled average of muscle activity was lowest in the coper group following the perturbation (POST-1: COP= 0.11± 0.02, CON=0.14±0.02, UNS= 0.16±0.02; POST-2: COP=0.10± 0.02,CON=0.13±0.02, UNS=0.16 ±0.02). **Conclusions:** Previous data has suggested that ankle copers may have a higher degree of joint stiffness measured both passively and reactively. Our data suggests that copers may be able to achieve this optimal joint stiffness regulation by using a decreased amount of overall muscle activity. Further analysis may reveal more complex selective recruitment and/or coactivation strategies to explain this phenomenon. This highlights a potential adaptation following injury that may prevent subsequent instability, and future research may attempt to identify interventions that may optimize joint stiffening strategies following injury. As previous studies have suggested stiffness of the passive structures are decreased among ankle copers, future research may investigate the relationship between stiffness of the capsuloligamentous structures, selected muscle activation and co-contraction.

Altered Ankle Kinematics During Gait Following Prolonged Exercise In Subjects With Chronic Ankle Instability

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Context: Kinematic differences in gait have been shown between individuals with chronic ankle instability (CAI) and healthy controls. Specifically, individuals with CAI tend to be more plantar flexed and inverted before, at, and post initial contact. However, it is unknown if these kinematic differences are exacerbated after exercise, which may increase sports-related re-injury risk. **Objective:** To compare ankle kinematics during walking and jogging on a treadmill between subjects with CAI and healthy controls following a prolonged period of exercise. **Design:** Descriptive laboratory study. **Setting:** Motion analysis laboratory. **Patients or Other Participants:** 15 physically active young adults with self-reported CAI (5 male, 10 female; age= 23.6±4.2years; height=171.8±9.9 cm; mass=72.9±12.6 kg; Foot and Ankle Ability Measure (FAAM)=86.9±8.2%; FAAM-Sport (FAAMS)=69.6±9.6%) and 15 healthy controls (5 male, 10 female; age=21.8±1.8 years; height =166.1±8.1cm; mass=64.1±11.8kg; FAAM=100.0 ± 0.0%; FAAMS= 100.0±0.0%) participated. **Interventions:** Subjects walked (3.0mph) and then jogged (6.0mph) while shod on a treadmill after a 36-minute exercise protocol. The exercise protocol consisted of six 6-minute cycles that included 5 minutes of inclined treadmill walking (3.0mph) followed by 1 minute of anaerobic jumping activities. As subjects ambulated on an instrumented treadmill with embedded force plates, a 12-camera motion analysis system captured 3-D ankle kinematics during one 15-second trial of walking and

another of jogging (average walking strides=10; average jogging strides=20). For each trial, individual strides were normalized to 100 increments. **Main Outcome Measures:** Frontal and sagittal plane ankle kinematics were recorded throughout the entire gait cycle for each speed. Group means and associated 90% confidence intervals (CI) were calculated for each group. Significant differences in the gait cycle were determined by identifying increments where the CI bands for the two groups did not cross each other. Mean differences and standard deviations between groups were calculated for these significant intervals. **Results:** While walking, the CAI group was less dorsiflexed than the control group from 33 to 52% of the gait cycle (mean difference =3.34±0.19ˆ) and more plantar flexed from 65 to 77% of the gait cycle (mean difference=5.22±0.72ˆ). While jogging, CAI subjects were less dorsiflexed than the control group from 5 to 14% of the gait cycle (mean difference=5.65±0.53ˆ). No significant differences were found in the frontal plane between groups at either speed. **Conclusions:** Following a prolonged period of exercise, individuals with CAI tended to be in a more plantar flexed position during gait compared to healthy controls. These kinematic changes may predispose patients with CAI to increased re-injury risk after prolonged physical exertion. To our knowledge, this is the first study that has examined gait kinematics in individuals with CAI following prolonged exercise.

Ankle Joint Coupling During Jogging With Chronic Ankle Instability

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Context: Altered joint coupling patterns between tibial internal/external rotation and rearfoot inversion/eversion during gait may play a role in chronic ankle instability (CAI). **Objective**: To identify differences in the shank-rearfoot coupling magnitude (m) and direction (theta) throughout the gait cycle between CAI and healthy control groups during barefoot and shod jogging. **Design**: Case-control. **Setting**: Motion analysis laboratory. **Patients or Other Participants**: Twenty-eight young adults (CAI: n=15, #previous ankle sprains=4.9±2.5; Control, n=13, #previous ankle sprains=0±0) participated. The Foot and Ankle Ability Measure (FAAM) and FAAM-Sport (FAAM-S) were used to identify the level of self-reported function of CAI subjects compared to controls (CAI: FAAM=92.1±5.8%, FAAM-S=74.8±13.3%, Control, FAAM =100±0.0%, FAAM-S= 100±0.0%). **Interventions**: Subjects jogged (2.68m/s) for 5 minutes on an instrumented treadmill in both barefoot and shod conditions. **Main Outcome Measures**: Using a 12 camera motion analysis system, shank rotation and rearfoot inversion/eversion kinematic data were collected. Theta and m values were calculated throughout the entire gait cycle for 3 consecutive strides using the Tepavac method of vector coding analysis for joint coupling. This method estimates the coupling behavior between the two coupled segments (in our case, shank rotation and rearfoot inversion/eversion) at each pair of consecutive data points throughout the stride cycle. Theta represents the vector coding angle between the two segments indicating the relative direction of the coupled motions, while m represents the magnitude of relative motion between the two segments. Each stride cycle was normalized to 100 data points representing the full gait cycle. At each point in the stride cycle, the average values for m and theta across the three strides were calculated for each individual and used for statistical analysis. Means and 90% confidence intervals for each group were calculated at each of the 100 points of the stride cycle. Group differences were determined by identifying periods in the gait cycle where the confidence intervals did not overlap. Group means (±SD) were calculated across these intervals and are presented as descriptive statistics. **Results**: In shod jogging, group differences in theta were found during mid-stance (18-21%, control= 60.27±4.09º, CAI=47.22±3.47º), early-swing (72-75%, control= 51.31±2.24º, CAI=39.35±2.26º) and late-swing (84-87%, control= 61.83±2.26º, CAI=52.82±3.57º) between CAI and controls. No differences in m were found in jogging shod. In barefoot jogging, theta differences were found during mid-stance (40-43%, control= 69.80± 7.15º, CAI=59.72 ±4.71º), and mid-swing (81-84%, control= 76.51±0.65º, CAI=65.89±3.13º) phase of gait. Differences in m were found in mid-swing (76-84%, control=2.77±0.17º, CAI= 1.33± 0.41º), and late-swing (97-100%, control=2.48±0.31º, CAI= 2.95± 0.01º). **Conclusion**: Differences in the direction and magnitude of the intersegmental joint coupling of frontal plane rearfoot and transverse plane shank motion indicate that individuals with CAI exhibit alterations in movement coordination during gait. These altered movement patterns associated with CAI may reveal information on the internal constraints associated with CAI.

Lower Extremity Surface Electromyography Measures During Walking In Subjects With And Without Chronic Ankle Instability

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Context: Ankle sprains are among the most common musculoskeletal injuries and many patients develop chronic ankle instability (CAI) following an initial sprain. Individuals with CAI exhibit proprioceptive and postural control deficits as well as altered osteokinematics during gait. Neuromuscular activity is theorized to play a pivotal role in CAI but deficits during walking are currently unclear. **Objective:** To compare neuromuscular activity in terms of time of activation and percent of activation time as demonstrated by surface electromyography (sEMG) amplitudes during walking between CAI and matched controls. **Design**: Descriptive laboratory study. **Setting**: Laboratory. **Patients or Other Participants**: 15 adults with CAI (height=173±11cm, mass=72±14kg, age=23±4, sex=M:5 F:10) and 15 matched controls (height=173±9cm, mass=71±18kg, age=23±3, sex=M:5 F:10) participated. **Intervention(s)**: Subjects walked on a treadmill at 4.83 km/h as sEMG signals were recorded from the tibialis anterior (TA), peroneus longus (PL), lateral gastrocnemius (LG), rectus femoris (RF), biceps femoris (BF), and gluteus medius (GM). Stride time was determined with footswitches. **Main Outcome Measures**: Time of activation relative to initial contact and percent of activation time across the stride cycle were calculated for each muscle. Muscle activation was determined for each muscle if the amplitude was 10 SD over the mean amplitude during quiet standing. A negative value for time to activation represents muscle activation prior to initial contact. Percent of activation was calculated as the proportion of the total time across the stride cycle that the amplitude was greater than the previously described threshold. Independent t-tests were performed for each dependent variable to compare groups. The level of significance was set a priori at pd”0.05 for all analyses. **Results**: The PL and RF were activated significantly earlier in the CAI group compared to the controls (PL: CAI=-66±98ms, Control=158±165ms, p<.001; RF: CAI=-144±147ms, Control=-36±111ms, p=.03). No other significant differences were noted between groups for time of activation (AT: CAI=-359±156ms, Control=-285±180ms, p=.24; LG: CAI= 179±136ms, Control=247±133ms, p=.17; BF: CAI=-225±98ms, Control=-180±80ms, p=.18; GM: CAI=-80±99ms, Control=-60±124 ms, p=.63). The PL was activated significantly more time across the stride cycle (p=.05) in the CAI group (36±10%) compared to the control group (23±22%). No other significant differences were noted between groups for measures of percent of activation time across the stride cycle (AT: CAI=53±27%, Control= 53±25%, p=.96; LG: CAI=21±19%, Control=19±12%, p=.58; RF: CAI=37±25%, Control=27±22%, p=.24; BF: CAI=29±20%, Control =28±18%, p=.81; GM: CAI= 27± 25%, Control+23±22%, p=.62). **Conclusions**: Activating the peroneus longus for a greater duration may increase fatigability and pre-activating prior to initial contact may decrease available motor units capable of protecting against inversion moments during episodes of ankle hyperinversion. Collectively, the demonstrated coping strategy in the CAI group may be physiologically inefficient when compared to healthy counterparts. Targeted therapeutic interventions for CAI may need to focus on restoring normal neuromuscular function during gait.

Individuals With FAI Display Decreased Fibularis Reflex Response During Dynamic Inversion Perturbations

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Context: Symptoms of Functional Ankle Instability(FAI) typically present during dynamic activities. However, neuromuscular deficits in participants with FAI are often investigated during static, standing conditions. In order to create a more accurate model, individuals with FAI should be investigated during more dynamic movement patterns. **Objective:** Investigate reflex responses in muscles throughout the lower limb and low back during sudden inversion perturbations in individuals with and without FAI while walking. **Design:** Cohort **Setting:** Research Laboratory **Participants:** Forty subjects (Control Group [n=20, 1.7m±1.1, 65.6kg±12.9, 20yo±2] FAI Group [n=20, 1.7m±1.3, 74.9kg±16.1, 22yo±3]) participated in the study. Subjects with no history of previous ankle sprains were placed in the control group, while subjects who scored less than 27 on the Cumberland Ankle Instability Tool and answered ‘yes’ to at least 5 questions on the Ankle Instability Instrument were placed in the FAI group. Subjects were excluded if they had a history of bilateral ankle sprains, previous lower extremity surgery, neurological disorders of the lower-limb, or other balance-affecting disorders. **Interventions:** Surface EMG data were obtained from the fibularis(FIB), gluteus medius(GM), and erector spinae(ES) of the injured/matched side as well as the fibularis(FIB_CLS), gluteus medius (GM_CLS), and erector spinae (ES_CLS) of the uninjured/matched contralateral side. All data were collected as subjects walked down a custom-built 7.2-meter long walkway. For each trial a random segment of the

walkway would open to 30° causing the ankle to invert. EMG signals were recorded with a BIOPAC Systems MP 150 telemetry system(BIOPAC Systems Inc, Goleta, CA) at 2kHZ, hardware filtered(500Hz) and rectified. Short-latency reflex (SLR) onset was calculated from door opening until EMG activation. Amplitude of SLR and long-latency reflex (LLR) were calculated and normalized using z-scores. For each dependent variable, group differences were evaluated using independent sample t-test's. **Main Outcome Measures:** Onset of the SLR and normalized SLR and LLR amplitudes of 6 muscles (GM,FIB, ES,GM_CLS, FIB_CLS,ES_CLS). **Results:** The onset of the SLR of the FIB was significantly later in the injured side of the FAI individuals (46.5 ± 6.8ms) when compared to the control group(41.8±3.7ms; *P*=0.009). Both the SLR and LLR amplitude were significantly smaller in the FIB muscle in the FAI group than in the control group([SLR: 3.95±2.08ms vs. 7.99±4.01; *P*< 0.001] [LLR: 3.99± 2.27ms vs. 6.98 ± 4.18; *P*<0.008]). No significant differences in latency or amplitude reflex responses were identified between the two groups in the GM, ES, FIB_CLS, GM_CLS, or ES_CLS (*P*>.05). **Conclusions:** The results of this investigation indicate that during a dynamic perturbation task individuals with FAI demonstrate longer fibularis muscle latencies on the injured side but display no significant changes in the proximal muscle groups. Additionally, short and long latency reflex amplitudes were significantly decreased in the FAI group.

Mechanical Laxity Is Greater In An Unstable Ankle Population Compared To Copers And Controls

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Context: Chronic ankle instability (CAI) commonly develops following lateral ankle sprain and appears to be multifactorial in nature. It is unclear to what extent mechanical laxity is present in a CAI population. **Objective**: To determine if there are differences in inversion talar tilt laxity measures between recreational athletes with CAI, a coper group with a history of ankle injury, and a control group with no history of ankle injury. We hypothesized the CAI group would demonstrate significantly greater talar tilt laxity. **Design**: Cross-sectional. **Setting**: Biomechanics Laboratory. **Patients or Other Participants**: Fifty-six volunteer recreational athletes divided into 3 groups. CAI: 8 males, 11 females, age 20.7±1.5 years, height 169.9±9.0 cm, mass 72.0±17.0 kg; Copers: 12 males, 3 females, age 22.2±4.3 years, height 176.7±10.8 cm, mass 74.6±13.1 kg; Controls: 6 males, 16 females, age 20.4±1.4 years, height 166.0.1±8.0 cm, mass 64.9±11.5 kg. CAI and coper groups reported history of previous moderate-severe ankle sprain. CAI group reported e"2 episodes of ankle instability in the last 12 months while copers and controls had none. CAI group had Cumberland Ankle Instability Tool (CAIT) score d"26, indicating poor function. Copers and controls scored e"28, indicating good function. **Interventions**: In a single test session, participants completed the CAIT and underwent lateral ankle ligament instrumented arthrometry for inversion talar tilt. A rater, with established reliability >0.80, performed the arthrometry. Participants' were positioned with the ankle in neutral and the knee slightly flexed while a 15dN force was applied. Three trials were collected. A one-way ANOVA with Tukey post-hoc testing was utilized with ˜ =0.05. **Main Outcome Measures**: CAIT scores were calculated and the maximum talar tilt angle was recorded and averaged across 3 trials. Group means were compared via one-way ANOVA. **Results**: Groups were not different in age or mass (*P*e"0.09). The coper group was taller than the controls (*P*=0.003). The CAI group (20.6±5.6) had significantly lower CAIT scores (*P*<0.001) than the control (29.8±0.5) and coper (29.3±0.9) groups indicating decreased function. The CAI group (26.6°±8.4°) demonstrated greater talar tilt inversion than the control (16.2°±11.0°) and coper (16.9°±9.8°) (*P*=0.003). **Conclusions**: The CAI group appeared to demonstrate decreased self-reported ankle function and increased mechanical laxity in the lateral ligaments as measured by instrumented talar tilt compared to the control and coper groups. There were no differences in laxity between controls and copers. In this recreationally active population, mechanical laxity may be a factor in decreased ankle function. Copers, who had an injury, may have reported better function because they were not lax and were comparable to controls. We attribute the group difference in height to unequal gender distribution. Future research should clarify the role of mechanical laxity in contributing to CAI.

Plantar Pressure Distribution Differences In Physically Active Individuals With And Without Functional Ankle Instability During A Side Cut Maneuver

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Context: Functional ankle instability (FAI) is a common condition in the physically active population. Individuals with FAI exhibit alterations in plantar pressure during gait when compared to healthy individuals; however, it is unknown if individuals with FAI demonstrate deviations in plantar pressure distribution while performing a side cut task. **Objective:** To assess differences in plantar pressure distributions while completing a side cut task in individuals with and without FAI. **Design:** Case-control. **Setting:** Outdoor FieldTurf and laboratory. **Participants:** Twenty physically active individuals with FAI (21.4±2.62yrs; 69.67±8.66kg; 167.2±4.93 cm; Cumberland Ankle Instability Tool (CAIT) Score= 23.95±3.41; Foot Posture Index (FPI) Score=2.0±3.18) and 20 individuals without FAI (22.40± 3.13yrs; 69.5±10.5kg; 169.6±6.18m; CAIT Score=29.25±0.78; FPI Score= 2.4±2.28). **Main Outcome Measure(s):** All participants filled out the CAIT to determine the presence of FAI. Foot type was assessed using the FPI and used for matching. Subjects ran at a self-selected pace for 10 meters and then performed a side cut task of 45 degrees on FieldTurf. Two trials were collected. Peak pressure (PP-kPa) and force-time integral (FTI-%bw/s) were measured using the PEDAR-x plantar pressure system (Novel, Inc., Munich) through a six-part mask [lateral (LF) and medial forefoot (MF),lateral (LM) and medial midfoot (MM), lateral (LR)and medial rearfoot (MR)]. Both measures were normalized to body weight. Separate 2(group) x 6(masks) repeated measures ANOVAs were used to assess differences for each dependent variable (PP and FTI) (˜≤0.05). Post hoc analyses were conducted using T-tests with a Bonferroni correction. **Results:** For FTI a main effect was detected for mask(P<0.001) (LF= 5.52±1.63%bw/s, MF= 14.01 ± 3.78%bw/s, LM=2.17±1.10%bw/s, MM=3.35±1.38%bw/s, LR= 3.19 ±1.74%bw/s, MR=3.54±1.79%bw/s) with MF> LF,LM,MM, LR,MR (P<.001), LF>LM,MM, LR,MR (P<.001), and LF<MF,LM,MM, LR,MR(P≤.001). A main effect was detected for group(P=0.015) with FAI individuals(5.69±0.2.05%bw/s) being higher than controls (4.89±1.60%bw/s). A significant mask by group interaction (P=0.033) was detected for FTI. The FAI group (6.11 ±1.91%bw/s) had increased FTI in the LF compared to the control group(4.93±1.04%bw/s)(P=.003). There were no other significant comparisons (P range = .18-.65). For PP, there was a main effect for mask(p<0.001) (LF= 221.15 ±72.16kPa,_MF=462.77±93.04kPa, LM=114.89±40.84kPa, MM=162.89±43.86kPa, LR=293.47±136.75kPa, MR=313.38±129.96kPa) with all masks being different (P<.001) except for LR and MR (P=.99), and LR and LF (P=.103). There was no main effect for group (FAI:263.96 ±91.87kPa; Control:258.89 ± 79.90kPa;P=0.75). There was no mask by group interaction(P=0.36). **Conclusions:** When performing a side cut task, individuals with FAI spend more time over the lateral forefoot when compared to healthy individuals. The increase in FTI over the lateral forefoot may enhance the chance of an inversion injury mechanism in individuals with FAI. Alterations in movement patterns identified by plantar pressure may be useful for future research in understanding contributing factors to FAI.

Postural Modulation Of Hoffmann Reflex Strongly Correlates With Postural Control In Patients With Chronic Ankle Instability

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Context: Decreased modulation of Hoffmann reflex (H-reflex) of the ankle stabilizing muscles during changes in body positions has been found in patients with chronic ankle instability (CAI) suggesting that neural alterations may be an underlying neurophysiological mechanism of postural control deficits associated with CAI. However, it is currently unknown whether this modulation is related to postural control measures in patients with CAI. **Objective:** To determine relationships between the H-reflex modulation of the soleus and fibularis longus and postural control measures in an upright position in patients with and without CAI. **Design:** Descriptive. Setting: Laboratory. **Patients or Other Participants:** Fifteen subjects with CAI (9 males, 6 females; age=23±5.8 years; height= 174.7± 8.1cm; mass=74.9±12.8kg) and 15 controls without any history of ankle sprains (9 males, 6 females; age 24±5.8 years; height=171.9±9.9 cm; mass=68.9±15.5 kg) participated. Interventions: Maximum H-reflexes (H-max) and motor waves (M-max) from the soleus and fibularis longus of the CAI-involved or side-matched limbs were recorded while subjects lied prone and then stood in bipedal and unipedal stances. Postural tasks of quiet bipedal and unipedal standing with eyes closed for 10 seconds were assessed with a forceplate. **Main Outcome Measures:** H-max was normalized to M-max to obtain H_{max}:M_{max} ratios for the three positions. For each muscle, H-reflex modulation was quantified with the percent change scores in H_{max}:M_{max} ratios calculated between: prone-to-bipedal (P-Bi) and bipedal-to-unipedal (Bi-Uni). Center of pressure (COP) data were used to compute 10 specific COP parameters including standard deviation, range, velocity, area, and time-to-boundary (TTB) minima. Pearson correlation coefficients (r) were calculated between H-reflex modulation and postural control measures. Results: There were 5 strong correlations (all Pd"0.05) between P-Bi modulation and bipedal COP measures found only in the CAI group with a range of r=-.639 to -.725 for 3 traditional COP measures and r=.588 to .608 for 2 TTB measures. Lower traditional COP and greater TTB measures reflect better postural stability, thus indicating that as H-reflex was more down-regulated, postural control measures improved. When pooling the data from both groups, there were 9 moderate relationships found in a range of r= -.374 to -.465 for 7 traditional COP measures and r=.490 to .493 for 2 TTB measures. For relationships between Bi-Uni modulation and unipedal COP measures, there were 3 strong correlations found in the CAI group in a range of r=-.606 to -.690 for 3 traditional COP measures, and 1 strong relationship (r=-.759) found in the healthy group. When combining group data, there were 7 moderate to strong correlations found in a range of r=-.394 to -.554 for 7 traditional COP measures. **Conclusions:** The results indicate that as H-reflex amplitude in a more challenging position is more down-modulated, the corresponding postural stability improves. This relationship was more evident in the CAI group.

The Relationship Between Joint Laxity And Physical Activity Levels

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Context: Ankle sprains remain one of the most common musculoskeletal pathologies. **Objective:** To determine if there is a relationship between ankle joint laxity and physical activity levels in those with chronic ankle instability (CAI). **Design:** Case Control Study. **Setting:** Controlled, research laboratory. **Participants:** Fifteen subjects with unilateral CAI (6 males and 9 females, age=21.2± 1.9yr., mass=71.9±11.7kg, ht=174.3±6.9cm) and fifteen healthy subjects (6 males and 9 females, age=20.4±2.1yr., mass=73.1±13.4kg, ht= 172.1± 5.5cm) participated in the study. **Interventions:** Mechanical joint stability was measured with an instrumented ankle arthrometer. The arthrometer measured ankle joint motion for anterior/posterior translation and inversion/eversion angular displacement. All subjects also filled out the foot and ankle ability measure (FAAM) and the FAAM sports subscale. After initial testing, all subjects were provided with a Digi-Walker SW-200 pedometer (New Lifestyles, Inc., Lees Summit, Missouri). Participants were instructed to wear the pedometer everyday for seven days and complete the daily step log. Bivariate correlations using Pearson Product Moments were made between all dependent variables taken on the CAI and health ankles. The level of significance was set a priori at $p \leq 0.05$ for all analyses. **Main Outcome Measures:** Anterior displacement (mm), posterior displacement (mm), inversion rotation (°), eversion rotation (°), and average daily step count. **Results:** Subjects with CAI had significantly less steps (p=.04)

compared to the healthy group. The average daily step count for the CAI group was 8,694.47±1,603.35 and for the healthy group 9,831.01 ±2,290.01. Subjects with CAI had significantly more ($p = .001$) anterior displacement (14.2mm ± 2.7) compared to the healthy ankles (10.6mm ± 1.8). There were no significant differences for posterior displacement or inversion/eversion rotation. Several significant bi-variate correlations were identified. The strongest relationship was between anterior laxity and average daily step count ($r = -.84$, $p < .02$). As anterior displacement increased average daily step count decreased. There was also a significant relationship with inversion rotation and average daily step count ($r = -.78$, $p < .047$). As inversion rotation increased average daily step count decreased. **Conclusions**: The results of this study indicate increased laxity in those with CAI may contribute to the decreased physical activity levels of these subjects. It is unknown if the decreased step count is due solely to increased joint laxity or potentially the corresponding changes in neuromuscular control that occur with joint instability. Decreased physical activity levels in this population is a concern, and interventions need to be designed to improve ankle stability and neuromuscular control to ensure subjects can participate in physical activity/exercise programs.

Posterior Hip Dislocation With Acetabular Wall And Femoral Head Fractures: A Case Report

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Background: We present the case of a posterior hip dislocation complicated by a posterior acetabular wall fracture and a femoral head fracture. A healthy twenty-two year old male division I club rugby athlete was running with the ball when he was tackled by two opposing players. During the tackle, his left knee directly impacted the ground while in a flexed and fixed position while his torso was forced anteriorly. The patient immediately complained of severe pain in the area of his hip and thigh and was unable to move his left leg. During physical examination his hip was found to be in a position of flexion, adduction and internal rotation. The patient was diagnosed on the field as having a posterior hip dislocation. An on-field reduction was not attempted. Instead, he was immediately immobilized to a spine board in a position of comfort and transported to the local emergency department. **Differential Diagnosis:** Pelvic ring fracture, acetabular fracture, femoral head or neck fracture, acetabular labral tear, sciatic nerve injury. **Treatment:** Radiographs taken at the emergency department revealed a posterior hip dislocation with posterior acetabular wall and medial femoral head fractures. Following a closed reduction, radiographs confirmed alignment of the femoral head however a fracture fragment was noted at the inferior aspect of the acetabulum. The patient was immediately referred to another hospital where an orthopedic surgeon performed an open arthrotomy with a posterior approach to remove the fragments. The procedure required surgical dislocation of the femoral head to obtain a clear view of all fragments. Post-surgery computed tomography (CT) scan and radiographs revealed a successful procedure with the hip complex in a concentric position. The patient was discharged six days post-surgery. **Uniqueness:** Hip dislocations are relatively uncommon during athletic events. When they do occur, they are usually associated with high-energy impact events like football and rugby. Dislocations complicated by fractures of both the acetabulum and femur are even more uncommon. These injuries generally require open reduction and internal fixation because of the instability created by the acetabular wall defect. This was not indicated for our patient however, as he was managed with a closed reduction only. **Conclusion:** Posterior hip dislocations with posterior acetabular wall and femoral head fractures are rare injuries that result from high-trauma mechanisms. When these injuries occur, early reduction procedures are indicated to reduce the risk of long-term complications such as avascular necrosis and degenerative joint disease. Post reduction imaging is then required to rule out associated fractures and intra-articular loose bodies. If loose bodies are found, as in the current case, surgical removal is necessary to prevent abrasive wear of the articular cartilage. Upon discharge, patient education regarding potential complications such as osteonecrosis of the femoral head, posttraumatic osteoarthritis and recurrent dislocation is also important. The acetabular and femoral head fractures increase the risk of posttraumatic osteoarthritis and other complications. At one year post-surgery our patient has progressed through rehabilitation and is now participating in lower extremity resistance training. However, he is still prohibited from running and participating in any contact sports.

Hip Injury In A Youth Football Player

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Background: A 10yo football player with no past history of lower extremity injury was running the football when he was brought to the ground and landed under multiple players. The athlete experienced immediate pain and difficulty bearing weight but was able to ambulate with a limp from the field. He was removed from play. Pain was diffuse about the hip, ROM was limited secondarily to pain. He reported no numbness or radiating pain following the injury. **Differential Diagnosis:** Contusion, slipped capital femoral epiphysis (SCFE), Legg-Calvé-Perthes disease, labral tear, avulsion fracture, or hip dislocation. **Treatment:** Athlete was referred to the local emergency department for evaluation. No abnormalities were noted on plain radiographs. Athlete was sent home on crutches and told to follow-up with his pediatrician. Upon seeing his pediatrician he was diagnosed with a contusion and instructed to remain on crutches until he could walk without a limp. Twenty-seven days post injury he was referred to a primary care sports medicine physician for further evaluation. At this time the athlete's primary complaint was pain mostly in the groin region with some pain in the lateral hip. He had full ROM with flexion and extension of the hip, knee and back, limited ROM with internal and external rotation of the hip. These deficits were further noted with the hip in a flexed position. Manual muscle testing for strength was 5/5 at the hip, knee and ankle. Straight leg raise test was negative bilaterally and he reported mild discomfort with logrolling of his left hip. Plain

radiographs again revealed no bony abnormalities. Given the patient's decreased hip motion and continued pain, he was referred for an MRI. This revealed a displaced posterior wall acetabular fracture, labrum avulsion as well as a subchondral fracture of the medial femoral head. The patient was then referred to a trauma surgeon for possible acetabular repair. Thirty days post injury the athlete was seen in trauma clinic. Exam was essentially unchanged from 3 days prior. Patient was diagnosed with a posterior wall acetabular fracture secondary to hip posterior dislocation with spontaneous reduction. Surgical repair of the fracture was determined to be the best option to return this patient to high level function given his age and risk for instability if not repaired. Surgery was performed 37 days post injury. An open posterior approach was used and a pelvic reconstruction plate was utilized to secure the posterior wall pieces. The patient was released 3 days s/p procedure with home exercise program and instructions to be toe touch weight bearing for 6 weeks post-surgery. At last follow-up the patient was healing well, hip rotational profile was symmetric, and all lower extremity muscles were firing appropriately. Patient will continue long-term follow-up with repeat radiographs to monitor for avascular necrosis but is expected to return to full function. **Uniqueness:** Hip dislocations in athletics are rare. Less than 5% of traumatic hip dislocations occur in individuals under age 15 and most are associated with high impact vehicular trauma. Pelvic fractures in adolescents are rare and only 10% of these fractures involve the acetabulum. In instances where spontaneous reduction occurs, diagnosis can be challenging, particularly when radiographs are normal. **Conclusion:** While hip dislocations are rare in the athletic population it is important for athletic trainers to be aware of the signs and symptoms of a severe hip injury. These injuries can go misdiagnosed if symptoms such as reduced rotational ROM are ignored and further assessment is not pursued.

Unicameral Bone Cysts Of The Proximal Femur With Subsequent Pathological Fracture: A Case Report

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Background: An 18 year-old physically active female (5'7", 120 pounds), presented with left hip pain of approximately three weeks duration, progressively worsening. She reported pain with hip flexion, external rotation and weight-bearing. There was no acute trauma or specific injury that could be determined. The initial examination by an athletic trainer demonstrated reduced range of motion secondary to pain during flexion, adduction, and external rotation, the presence of a rightward antalgic gait, and pain during weight-bearing. The patient was given crutches, instructed to be non-weight bearing (NWB), and was referred to an orthopedic surgeon due to loss of function and pain level. X-rays of the left femur and pelvis demonstrated multiple lucencies. Physical examination demonstrated continued pain with hip flexion, external rotation, and weight-bearing. **Differential Diagnosis:** Hip sprain/strain, muscle tear, fracture, unicameral bone cysts, sarcoma, osteomyelitis, leukemia, osteoporosis. Treatment: Immediate referral for an MRI, CT scan, and an evaluation by a musculoskeletal oncologist were ordered. The musculoskeletal oncologist confirmed the diagnosis as multiple benign neoplasms of the proximal femur. Following the two specialists' evaluations, the athlete continued NWB status while awaiting outpatient surgery, approximately 2 weeks later. The initial surgery for unicameral bone cysts of the femoral neck and lesser trochanter and pathological fracture of the femoral neck consisted of

curettage and packing of the lesion with OsteoSet Pellets, a synthetic bone graft. The patient was NWB until approximately two weeks status-post surgery when sutures were removed and formal physical therapy was initiated. Gentle progression from partial weight-bearing to full weight-bearing was achieved over a period of four weeks. X-rays were repeated at each post-operative visit at approximately six week intervals. Once discharged from physical therapy, the patient continued a home exercise program (HEP). The athlete was advised that she could return to participation in recreational and/or competitive sport as long as she was pain-free. Almost two years after surgery, the athlete still complained of occasional pain and x-rays revealed that the synthetic graft did not satisfactorily obliterate the lesions as well as desired by the surgeon, and an open-reduction internal fixation (ORIF) was recommended in anticipation of the patient's start of a potentially physically strenuous program of study. An ORIF with curettage and packing of the lesion with bone allograft was performed nearly 2 years following the initial surgery. The patient was NWB for approximately two weeks status-post surgery when sutures were removed. Only two to three visits of formal physical therapy were ordered and then the patient was directed to repeat the HEP as previously prescribed on the initial surgery. The patient was permanently restricted from high-impact sports. **Uniqueness:** Unicameral bone cysts (UBCs) or simple bone cysts (SBCs) are of an unknown etiology, though it is suspected that venous obstruction elevates interosseous pressure, leading to cyst formation. These cysts are often asymptomatic and found incidentally on imaging for separate complaints. They are reported to be self-limited, stabilizing or spontaneously resolving following skeletal maturity. These lesions can cause severe, performance-limiting pain in young adults during strenuous activity but minimal to no pain during sedentary activities. **Conclusions:** Athletic trainers should consider the possibility of oncology-related diagnoses when evaluating young athletes for orthopedic injuries as they may present similar to common sprains/strains and joint aches. Radiographic imaging should be obtained to rule out common diagnoses, such as fracture or avulsions, and to rule out oncology-related diagnoses, such as UBCs, SBCs, or other benign tumors of the bone.

The Evaluation And Treatment Of A Femoroacetabular Impingement In A Young Soccer Player: A Case Report

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Background: This case involves a male, 15-year-old avid soccer player (5'6", 118.8 lbs); he is a right-foot dominant defensive right back. The athlete presented with left anterior hip, groin, and buttock pain for over a year while playing competitive soccer. No specific incident of trauma or mechanism of injury was reported. His symptoms progressively worsened causing an abnormal walking gait. The family scheduled a consultation with a pediatric orthopedic physician due to restricted movements, uncomfortable pain and declining athletic performance. **Differential Diagnosis:** Adductor or flexor strain, apophysitis, internal or external snapping hip, athletic pubalgia, slipped capital femoral epiphysis, and labral tear. **Treatment:** Upon initial evaluation the physician immediately ordered magnetic resonance imaging (MRI) of the pelvis and hip magnetic resonance arthrogram (MRA) that same day due to a positive hip scouring and anterior impingement test. Clinical impression of the pelvis MRI produced abnormal morphology of both hips in a fairly symmetric behavior. Next, a left hip MRA was performed using guided fluoroscopy. The results were remarkable and compatible with femoroacetabular impingement (FAI) both cam and pincer lesions bilaterally along with a left labral tear. Together the family chose arthroscopic surgery of the FAI for debridement of the osseous prominence, acetabular overgrowth, and to repair the left labral defect of the hip in order to continue playing at the elite level. Surgery was scheduled 6 weeks after the evaluation and diagnostic assessments. The

surgeon used a Smith and Nephew distraction table and applied three knotless Smith and Nephew rapture anchors (2.9 cm) to repair the labrum, then, proceeded with the acetabuloplasty and femoroplasty. Rehabilitation was prescribed with restrictions, including NWB for 6 weeks and TTWB to PWB for an additional 2 weeks. The protocol advised for no hip adduction for 6 weeks and included AROM limitations of hip flexion, extension, and external rotation. Rehabilitation began with hip isometrics and progressed to full AROM with NWB core exercises. He began biking when hip flexion was tolerable. After week 8, he began shuttle press, balance and proprioception exercises. Jogging was introduced at week 10 using a hydrotrack, with normal progressive running at 3 months. The final phase began at 4 months and included soccer specific drills, plyometrics and agility patterns. The athlete was cleared to play at 5 months and finished the entire club soccer season without setbacks. **Uniqueness:** FAI is less common in adolescent athletes. Previous research suggests that FAI in males typically produces only the cam lesion, making this a rare case due to the athlete's age, sex and morphological mixture of osseous impingements (both cam and pincer lesions). In addition, the timeframe between initial symptoms and medical treatment is remarkable since no signs of degenerative changes within the left hip were reported. **Conclusions:** FAI leads to restricted hip motion, progressive damage to the labrum and degenerative intra-articular changes. Most reported adolescent cases present with either the cam or pincer lesion and not a combination of both. It is important to understand the etiology of FAI in order to stop further damage of intra-articular structures. Due to the underlying structures FAI can be difficult to diagnose. Athletic trainers need to be aware of the etiology involved with hip pathologies in order to make sure our athletes continue to play their respected sport without causing further damage. Future research should focus on FAI in the adolescent athlete since there is limited literature readily available.

Alterations In Biomarkers Following Anterior Cruciate Ligament Injury: A Systematic Review

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Context: Anterior cruciate ligament (ACL) ruptures occur in approximately 250,000 Americans each year, with these patients experiencing an 8-10 fold increase in risk of developing knee osteoarthritis. Osteoarthritis is primarily diagnosed radiographically, but by the time radiographic changes appear, considerable damage has occurred and treatment is challenging. Biochemical markers (biomarkers) of cartilage degradation may be detectable early following ACL injury before radiographic osteoarthritis has developed. **Objective:** Systematically review the literature to determine the magnitude of differences in biomarker concentrations following injury and ACL reconstruction (ACL-R) compared to healthy controls. **Sources:** Web of Science was searched from 1960 through November 9, 2012 with the search terms "anterior cruciate ligament injury" and an exhaustive list of classifications of biomarkers. Bibliographies of pertinent studies were cross-referenced for additional relevant studies. **Study Selection:** Five studies assessed biomarker concentrations in either ACL-deficient (ACL-D) or ACL-R patients compared to healthy controls. We excluded studies if: treatments outside of standard physical rehabilitation were given in attempt to alter biomarker concentrations; a control group was not used for comparison; means and standard deviations were not presented; or studies used animal models. **Data Extraction:** Means and standard deviations were extracted from each study to compare biomarker concentrations in ACL-R and ACL-D

patients to healthy controls. Cohen's effect sizes (*d*=treatment–control/ pooled standard deviation) with 95% confidence intervals (CI) were calculated for each biomarker to allow for comparisons between groups. **Data Synthesis:** For ACL-D patients, the strongest effect was found at 12 months following injury for serum chondroitin sulfate epitope (WF-6; *d*=7.57,CI=6.43-8.60). A strong effect for synovial fluid (SF) glycosaminoglycan (GAG) concentration was seen immediately following injury (*d*=1.06, CI=0.26-1.81), and moderate effects were found at 5.4 and 388.4 weeks post-injury (*d*=0.69,CI=-0.22-1.54; *d*=-0.56,CI=-1.32-0.23, respectively). Weak effects were found for SF concentrations of aggrecan at all time points (0.7weeks:*d*=0.26,CI=-0.05-0.99; 5.4weeks:*d*=0.35,CI=-0.52-1.20; 67.3weeks:-0.14,CI=-0.98-0.70; 388.4weeks:*d*=-0.13,CI=-0.88-0.64), as well as serum levels of hyaluronic acid at 12 months in ACL-D patients (*d*=-0.30,CI=-0.70-0.12). SF GAG concentrations at 67.3 weeks in ACL-D patients were weak (*d*=-0.39,CI=-1.22-0.47). Following ACL-R, weak effects at all time points were observed for urine levels of C-telopeptide fragments of type II collagen (CTX-II) following reconstruction (4weeks:*d*=0.15,CI=-0.38-0.67; 8weeks:*d*=0.11,CI=-0.41-0.64; 12weeks:*d*=0.09,CI=-0.44-0.61; 16weeks:*d*=0.01,CI=-0.52-0.53), however moderate effects were seen for SF CTX-II one year following injury in ACL-D patients (*d*=0.53,CI=0.04-1.02). **Conclusion:** Alterations in biomarker concentrations are present following ACL injury in both ACL-R and ACL-D patients, suggesting the process of degeneration may begin immediately following injury. The strongest effects were found in ACL-D patients in serum levels of WF-6 one year following injury and GAG concentrations immediately following injury. Future studies should aim to determine which biomarkers are the strongest predictors of osteoarthritis development following ACL injury and ACL-R, ultimately allowing for early detection of cartilage degeneration.

Elevated Biomarkers Of Cartilage Catabolism And Inflammation In Athletes With Femoroacetabular Impingement

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Context: Femoroacetabular impingement (FAI) is a common hip condition in athletes that leads to the development of early cartilage and labral damage in the non-dysplastic hip. While FAI surgery improves the kinematics after surgical correction of FAI, no specific prognostic indicators of osteoarthritis that correlate with joint injury or assess the efficacy of hip preservation surgery have been reported to-date. Cartilage oligomeric matrix protein (COMP) is an extracellular matrix protein that is an established marker of cartilage catabolism, and C-reactive protein (CRP) plays an important role in initiating inflammatory processes and is commonly used as a biomarker of inflammation.**Objective:** To determine if athletes with FAI have elevated biomarkers of cartilage metabolism and inflammation, we measured COMP and CRP levels in asymptomatic athletes with FAI and compared these to matched asymptomatic athletes without hip deformity. We hypothesized that athletes with FAI would have elevated levels of COMP and CRP. **Design:** Cohort study. **Setting:** Research laboratory. **Patients or Other Participants:** Male athletes with radiographically confirmed FAI (N=10, mean age 23.1±6.4, Tegner Activity Level 7.3±2.9, BMI 26.5±3.5) were compared to age and activity matched males athletes with radiographically confirmed absence of FAI or dysplasia (N=19, mean age 22.3±3.4, Tegner Activity Level 7.7±1.0, BMI 26.2±6.5). This study had IRB approval. **Interventions:** Radiographs were taken of subjects

and a board certified, fellowship trained musculoskeletal radiologist determined the presence or absence of FAI. Plasma was prepared from blood that was drawn from an antecubital vein. **Main Outcome Measures:** Circulating levels of COMP (R&D Systems) and CRP (Calbiotech) were measured using ELISAs. Subjects also completed SF-12 and Hip disability and Osteoarthritis Outcome Score (HOOS) surveys. Differences between groups were tested with t-tests ($P<0.05$). **Results:** Compared with control athletes, athletes with FAI had a 24% increase in COMP levels ($P<0.05$) and a 376% increase in CRP levels ($P<0.05$), as well as a 22% decrease in SF-12 physical component scores ($P<0.05$), and decreases in all of the HOOS subscale scores ($P<0.05$). **Conclusions:** This is the first study to-date that demonstrates significant increases in the levels of circulating biomarkers of inflammation and chondral injury in athletes with FAI compared to control athletes. These results demonstrate that chondral injury secondary to the repetitive microtrauma of FAI can be reliably detected, and offer future promise for the use these biomarkers as tools to identify at-risk athletes and assess the efficacy of therapeutic interventions such as hip preservation surgery in reducing inflammation, cartilage degeneration, and reducing the likelihood of developing osteoarthritis.

ACL Volume And Width Are Correlated With Anterior-Posterior Knee Laxity

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Context: Greater knee joint laxity has been associated with an increased risk of ACL injury. Mechanistically, multiple factors have been attributed to the magnitude of joint laxity. It is unknown if knee joint laxity is related to bony joint structure and ACL geometry. **Objective**: To determine the relationship between ACL and femoral notch geometry obtained via magnetic resonance (MR) imaging with anterior (AKL) and posterior (PKL) knee joint laxity. **Design**: Cross-sectional. **Setting**: Controlled Laboratory. **Participants**: Twenty-two recreationally active females (1.67±0.7m, 65±12.1kg, 21.4± 3.07yrs). **Interventions**: MR scans of the knee were performed and AKL and PKL were obtained via a commercial joint arthrometer. **Main Outcome Measures**: The entire ACL was segmented and manually traced across multiple slices from which ACL volume was calculated. ACL width was calculated as the width of a line drawn perpendicular to Blumensaat's line at the notch outlet that transected the ACL. Notch angle was measured as the angle formed by the intersection of the line parallel to the posterior cortex of the femur and Blumensaat's line. Ten particpants' MR data were assessed on two separate occasions to establish measurement reliability and precision. Joint laxity was measured as the anterior and posterior displacement of the tibia relative to the femur (mm) at 130N and 89N of force, respectively. Pearson correlations examined relationships among variables. **Results**: Strong measurement consistency ($ICC_{2,1}$) and precision (±SEM) were established for ACL volume (0.97±36.1mm^3); ACL width (0.98±0.3mm); and notch angle (0.97±1.1°). Mean ACL volume = 1320.6±183.5mm^3; mean ACL width = 5.9±1.3mm; mean notch angle = 37.1±6.2°; mean AKL = 7.2 ± 1.9; mean PKL = -1.7± 0.3. ACL volume was significantly correlated with ACL width (r= .907, P=.001), AKL (r= -.676, P=.032), and PKL (r=.789, P=.007). Smaller, but significant correlations were noted between ACL width with AKL (r=. -.466, P=.029) and PKL (r=.434, P=.049). There were no correlations between notch angle and AKL or PKL (P>.05). **Conclusions**: Greater AKL and PKL were associated with an ACL that was smaller and thinner. Collectively, this work suggests that clinically available measures of knee laxity are indicative of ACL geometry measures. A better understanding of the relationship between ACL geometry and knee laxity may advance prevention efforts. Future work should determine whether alteration of ACL geometry as a result from repetitive loading can be measured via simple clinical measurement such as joint laxity.

Relationships Between ACL-Injury Related Knee Mechanics During Double-Leg Jump Landings And Side-Step Cuts

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Context: One limitation of current anterior cruciate ligament (ACL) injury research is that knee mechanics related to ACL-injury risk are often evaluated during different types of movement tasks (e.g., landing vs. side-step cut, double-leg vs. single-leg). Two commonly used tasks are the double-leg jump landing and the side-step cut. However, it is currently unknown whether an individual's knee biomechanics during these tasks are related; and consequently, whether findings from studies utilizing these different tasks can be directly compared. **Objective:** To evaluate relationships between ACL-injury related knee biomechanics in participants performing double-leg jump landings (DLJL) and side-step cuts (SSC). **Design:** Cross-sectional. **Setting:** Research laboratory. **Patients or Other Participants:** Twenty-one healthy, physically active volunteers (12 Males, 9 Females, Age: 20.9±1.5 years, Height: 1.70±0.10 m, Mass: 72.76±11.31 kg). **Interventions:** Lower extremity biomechanics of the dominant limb were assessed via an optical motion capture system interfaced with two force plates as participants completed five DLJL from a 30 cm high box positioned 50% of their height behind the force plates; and five 45 SSC on the dominant limb. **Main Outcome Measures:** Sagittal and frontal plane knee angles at initial contact (IC) and peak knee valgus angle during the loading phase (IC to peak knee flexion) were identified. Internal net joint moments were calculated using standard inverse dynamics procedures, and the peak knee extension (pKEM) and knee varus (pKVM) moments during the initial 20% of the loading phase were identified. The relationships between the mean values for each biomechanical measure during the two movement tasks were assessed via Pearson correlation coefficients (d•0.05). **Results:** Greater IC (1.74±2.88°) and peak (-2.43±4.47°) knee valgus angles during DLJL were associated with greater IC (0.11±3.45°) and peak (-2.51±3.28°) knee valgus angles during SSC (IC: r = 0.710, $p < 0.001$; Peak: r = 0.778, $p < 0.001$). Though not statistically significant, there was also a trend for greater pKEM during DLJL (159.79±40.22 Nm) to be associated with greater pKEM during SSC (106.99±32.65 Nm; r = 0.418, $p = 0.059$). However, no relationships between IC knee flexion angles (DLJL: 21.60±4.60°; SSC: 25.97±6.81°; r = 0.181, $p = 0.432$) or pKVM (DLJL: 25.50±15.04 Nm; SSC: 56.34±26.66 Nm; r = 0.110, $p = 0.635$) during DLJL and SSC were identified. **Conclusions:** Participants exhibiting higher-risk frontal plane knee positions do so during both DLJL and SSC; but the magnitudes of IC knee flexion angle during these tasks appear to be unrelated. Conversely, while there was a trend for participants to exhibit greater pKEM during both tasks, we failed to identify a relationship between the magnitude of pKVM during DLJL and SSC. As such, caution should be exercised when evaluating IC knee flexion and pKVM results from studies utilizing these different movement tasks.

The Relationship Between Performance On Clinical Balance Tests After Anterior Cruciate Ligament Reconstruction

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Context: Balance deficits have been reported in individuals after anterior cruciate ligament (ACL) injury. The Balance Error Scoring System (BESS) test and the Star Excursion Balance Test (SEBT) are common clinical balance assessment tools. There are limited data comparing performance on these tests after an ACL reconstruction. **Objective:** To determine if there is a correlation between the BESS and the SEBT tests in individuals who have had an ACL reconstruction. **Design:** Correlation study **Setting:** Laboratory **Patients or Other Participants:** 18 healthy and active participants (10 females, 8 males, Age: 21.8±4.4 years, Mass: 75.2±10.43 kg, Height: 172.8±7.6 cm) with a history of ACL reconstruction volunteered to participate in this study. **Interventions:** Participants completed the BESS test and SEBT on their injured (most recent reconstructed ACL) and uninjured limbs in a randomized order. Participants were videotaped while they balanced in 3 different stances (Double-limb, Single-limb, Tandem) on two surfaces (flat or unstable) for the BESS test. A single rater, blinded to limb, recorded the errors from the videotape. A single rater measured the participants' reach distance of two trials in three directions (anteriorly, posteromedially, posterolaterally) for the SEBT. **Main Outcome Measures:** The BESS test and SEBT are valid and reliable tools for measuring balance. The errors from each stance and surface were summed to calculate a Total BESS score. The average

distances for each direction were summed into a composite SEBT score normalized by leg length. Pearson correlation coefficients were calculated to evaluate the relationship between BESS test and SEBT on both limbs (˜<.05). **Results:** There was no significant correlation between the BESS test (Injured BESS Total=6.7±2.9, Uninjured BESS Total=6.5±3.1) and the SEBT (Injured SEBT Total=0.48 ±0.10, Uninjured SEBT Total=0.49±0.10) for injured limb (r=0.26, P=0.30) or for uninjured limb (r=0.13, P=0.62). **Conclusions:** The BESS test and SEBT appear to measure different aspects of balance and function. Therefore, these clinical balance tests should not be used interchangeably in individuals after an ACL reconstruction. Clinicians may consider using both tests to evaluate balance deficiencies and assist return to play decisions.

Lower Extremity Biomechanics In Individuals With And Without Anterior Knee Pain During A Single Leg Drop Landing Task

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Context: Individuals with anterior knee pain (AKP) experience peripatellar pain during repetitive knee flexion associated with weight-bearing activities. Differences in lower extremity(LE) kinematics during jumping tasks have been demonstrated, however information on landing utilizing a single leg drop does not exist for AKP individuals. **Objective:** To examine differences in LE kinematics in individuals with AKP compared to healthy individuals during single leg drop landings. **Design:** Case-Control **Setting:** Laboratory **Participants:** Twenty-two physically active adults age 18-30 (11 AKP;169.72±7.0cm; 67.08±15.81kg; Kujala:70.73±8.68) (11 Control; 170.23±7.24cm; 67.28±12.62kg) who exercised a minimum of 3x/week for at least 30 minutes volunteered for this study. AKP participants had pain for a minimum of 3 weeks, during physical activity, prolonged sitting, jumping, and/or squatting, and the control group was free of LE injury and had no history of AKP. **Intervention:** Each subject performed five trials of a single leg drop landing task from three different heights during one testing session. The task required the participant to perform a single leg drop landing from a 20, 30, and 40 centimeter(cm) high box placed 10cm behind a force plate and remain on the force plate for ~2 seconds. Three-dimensional kinematics of the LE were obtained using an 8 camera motion capture system. **Main Outcome Measurements:** Independent variables were group [AKP, Control(Con)] and box height (20, 30, and 40cm). Dependent variables included sagittal and frontal plane transverse plane knee and hip angles at initial contact(IC) and maximum knee flexion(MaxKF). Separate 2x3 ANOVAs were performed for each variable. In the event of a significant (d".05) interaction or main effect, Fisher's LSD post-hoc tests were performed on all pairwise comparisons. **Results:** At IC there was a main effect for box height for ankle dorsiflexion(P=0.012) with differences between 20cm(-17.85±1 1.26°) and 30cm(-21.05±8 .44°)(P= 0.027), and 20cm(-17.85±11.26°) and 40cm (-21.06±7.22°)(P=0.03), and hip abduction(P=0.001) between 20cm (-6.42±10.78°) and 30cm(-8.58± 12.94°) (P=0.007), 20cm(-6.42± 10.78°) and 40cm(-9.4± 14.45°) (P=0.009). At MaxKF there was a main effect for box height (P=0.001) at knee flexion (KFL) between 20cm (-49.81±7.08°) and 30cm(-52.13± 6.24°)(P=0.001), 20cm(-49.81±7.08°) and 40cm(-55.36±9.15°)(P=0.001), 30cm(-52.13 ±6.24°)vs. 40cm(-55.36± 9.15°) (P= 0.005) and hip flexion (HFL) (P=0.002) between 20cm (23.13 ±25.14°) and 40cm(28.02 ±25.33°) (P=0.002), and 30cm (23.8±23.21°) and 40cm (28.02 ±25.33°)(P=0.008). There was a main effect for group for KFL(AKP: -48.43±7.16°;Con: 56.43 ±7.16°) (P=0.017). No other significant findings were present. There were no significant group x height interactions for any measure(P>0.05). **Conclusion:** Individuals with AKP demonstrate biomechanical differences in KFL at the instance of MaxKF during a single leg drop landing compared to healthy individuals. The AKP group demonstrated less KFL at MaxKF suggesting that they employ a stiffer landing pattern and may not attenuate the forces imposed on the LE as well as a healthy individual. The decrease in KFL may serve as a coping mechanism for the individuals with AKP to reduce pain during landing activities.

Comparison Of Triceps Surae Musculotendinous Stiffness, Geometry, And Architecture In Male Runners With And Without A History Of Tibial Stress Fracture

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Context: Previous research has identified greater lower extremity joint stiffness in runners compared to non-runners, and in runners with a history of tibial stress fracture (TSF) compared to healthy runners. While musculotendinous stiffness (MTS) is the largest contributor to joint stiffness, it is unclear what factors contribute to greater MTS in runners with a history of TSF. **Objective:** To compare triceps surae MTS, and muscle architecture and geometry between runners with and without a history of TSF. We hypothesized that previously injured runners would have greater MTS compared to healthy runners and differ in medial gastrocnemius (MG) architecture and geometry demonstrated by greater cross-sectional area (CSA), muscle thickness (MT), fascicle length (FL), and pennation angle (PA). **Design:** Cross-sectional. **Patients or Other Participants:** Eight healthy male runners (age = 20.8 ± 2.6 years; mass = 66.5 ± 9.4 kg; weekly running amount = 86.4 ± 31.8 km) and eight male runners with a history of TSF (age = 21.9 ± 3.0 years; mass = 65.6 ± 5.4 kg; weekly running amount = 78.9 ± 22.2 km) were recruited from community running groups and the university's varsity and club cross-country teams. Injury status was determined via self-report. **Interventions**: Triceps surae MTS was estimated from the damped frequency of oscillatory motion about the ankle following perturbation under loading equivalent to 45% of maximal voluntary isometric contraction (MVIC) of the plantarflexors. Ultrasound imaging was used to measure architecture and geometry of the MG. **Main Outcome Measures:** Geometric and architectural properties of the MG included CSA,MT, FL, and PA. MG strength was estimated via plantarflexion MVIC. Triceps surae MTS was standardized to body mass. All outcome measures were compared between groups via separate one-way analyses of variance. **Results**: Previously injured runners had greater normalized triceps surae MTS compared to healthy runners (178.4 ± 45.3 N/cm/kg vs. 112.7 ± 38.5 N/cm/kg; p = 0.007). No differences were found in CSA (680.5 ± 131.1 mm^2 vs. 619.8 ± 105.4 mm^2; p=0.325), MT (18.3 ± 2.3 mm vs. 17.1 ± 3.0 mm, p=0.0.382), FL (58.4 ± 11.4 mm vs. 53.0 ± 8.0 mm; p=0.292), PA (25.3 ± 4.0° vs. 24.8 ± 3.9°, p=0.810) or MVIC (51.5 ± 8.5 kg vs. 47.4 ± 15.2 kg; p = 0.518) between previously injured and healthy runners. **Conclusion**: MTS is a modifiable characteristic, and reducing triceps surae MTS may reduce the risk of TSF in male runners. Muscle crossbridge formation at a given percentage of MVIC, muscle architecture, and muscle geometry did not vary between groups. Therefore, the difference in MTS between previously injured and healthy runners is likely attributable to differences in tendon stiffness. Future research is required to determine the contribution of tendon stiffness to MTS in the lower extremity.

Combined Effect Of Static And Dynamic Posture May Be Predisposition To Medial Tibial Stress Syndrome

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Context: Characteristics of multiple static postural measures among those with Medial Tibial Stress Syndrome (MTSS) have not been examined. Furthermore the difference of dynamic postural measures between MTSS patients with and without static postural malalignments may provide better information to understand the importance of dynamic postural measures that may elicit MTSS. **Objective:** To identify multiple static postural characteristics of MTSS and investigate the dynamic postural characteristics of MTSS patients with and without static malalignments. **Design:** Case controlled study. Setting: Laboratory. **Patients or Other Participants:** A total of 74 recreational and competitive runners [37 normal (23.9±.4 years), 37 MTSS injured (24.0±.3 years)] were recruited. **Interventions:** Seven alignments (standing rearfoot angle, navicular drop, pelvic tilt, tibial torsion, tibial varum, femoral anteversion, weight-bearing Q-angle) were measured and entered into a hierarchical and K-means cluster analysis to identify the cluster which contained the majority of MTSS subjects. A total of three clusters were identified. Seven [MTSS without malalignment ($MTSS_{dyn}$) out of 16 subjects (the rest of 9 subjects were normal group) had MTSS in cluster one. Twenty-seven [MTSS with static malalignment ($MTSS_{mal}$)] out of 36 subjects [the remaining 9 subjects were no MTSS with static malalignment ($noMTSS_{mal}$) had MTSS in cluster two. Three ($MTSS_{dyn}$) out of 22 subjects (the rest of 19 subjects were normal) had MTSS in cluster three. Therefore, a total number of subject in four

groups were as follows: $MTSS_{mal}$ (n=27), $MTSS_{dyn}$ (n=10), no$MTSS_{mal}$ (n=9), and normal (n=28) groups. **Main Outcome Measures:** Maximum 3-D joint kinematics were collected with Vicon motion analysis system while jogging (2.65m/s, 120Hz). In order to confirm the characteristics of three clusters, a one-way ANOVA was performed to examine group (cluster) differences of static postural measures. One-way ANOVA tests were performed to examine differences across the 4 groups of dynamic postural measures assessed during jogging. **Results:** The characteristics of cluster two were greater valgus standing rearfoot angle (cluster1: 5.60°±2.49°; cluster2: 7.14°±3.06°; cluster3: 5.14°±2.71; P=.026), anteverted femoral head (cluster1: -6.75°±2.98°; cluster2: 7.08°±3.22°; cluster3: 4.45°±4.16°; P<.001), valgus WB Q-angle (cluster1: 18°±4.29°; cluster2: 19.53°±4.45°; cluster3: 11.52°± 3.98°; P<.001), and externally rotated tibia (cluster 1: 24.13°± 7.34°; cluster2: 30.42°±4.66°; cluster3: 17.64°± 5.18°; P<.001). $MTSS_{mal}$ (2.74°±.60°) showed significantly higher max eversion (F3,70=5.95; P<.001) as compared with normal (-.51°±2.47°); MTSS (2.40°±.96°) showed significantly higher max eversion as compared with normal (-.51°±2.47°); $MTSS_{mal}$ (14.67°±.78°) showed significantly higher max hip adduction (F3,70=3.32; P=.025) as compared with normal (11.91°±.72°); and $MTSS_{mal}$ (11.05°±1.56°) showed significantly higher max knee internal rotation (F3,70=383.00; P=.00) as compared with normal (2.12°±1.45°). **Conclusions:** Individuals with static postural measures such as increased standing rearfoot angle, femoral anteverion,WB Q-angle, and external rotation of tibia may be predisposed condition for MTSS in combination with joint kinematics such as rearfoot everion, hip abduction, and knee internal rotation.

Hamstring Strain Injury History And Muscle Strength, Volume, And Flexibility In Intercollegiate Sprinters And Jumpers

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Context: Sprinters and jumpers have a high incidence hamstring strain injury, but limited research has been performed investigating long-term effects of hamstring injury on muscle characteristics. **Objective:** To compare side-to-side symmetry in measures of thigh muscle strength, volume, and flexibility in intercollegiate sprinters and jumpers with and without a history of unilateral hamstring strain injury. **Design:** Descriptive laboratory study. **Setting:** NCAA Division I university. **Patients or Other Participants:** 21 intercollegiate sprinters and jumpers (12 males, 9 females; age=19.1±1.3 years; height=1.8±0.1 m; mass= 70.2±9.0 kg) participated. Seven (5 males, 2 females) had a history of unilateral hamstring injury while 14 (7 males, 7 females) reported no history of hamstring injury. Individuals reporting bilateral hamstring injury history were excluded from participation. **Interventions:** Isometric, concentric, and eccentric hamstring and quadriceps strength was collected using an isokinetic dynamometer. Maximal isometric contractions were performed at 60° knee flexion, while concentric and eccentric isokinetic testing was performed at 180°/s. Peak torques were normalized to body mass. Muscle volumes of the semimembranosus, semitendinosus, biceps femoris long head, biceps femoris short head, total hamstrings, and total quadriceps were calculated from magnetic resonance images using an established segmentation routine. Muscle volume measures were normalized to a product of subject mass and height. Hamstring flexibility was assessed with a 90/90 test and hip flexor flexibility was assessed with the Thomas test with measures taken of both the shank and thigh. **Main Outcome Measures:** In the injured group, limb-to-limb symmetry ratios of the injured to uninjured limb were calculated for all measures. In the control group, a matching routine was used to assign each subject with a "sham" injured limb prior to computation of symmetry ratios. Independent t-tests were used to compare the symmetry ratios between groups. **Results:** The previously injured group demonstrated decreased total quadriceps volume compared to the non-injured group (injured=.96±.04, healthy=1.0±.04, p=.04). No significant symmetry ratio differences were found in any other measures (semimembranosus volume: injured=.96±.09, control=1.03±.10, p=.13; semitendinosus volume: injured=1.01±.10, control=.96±.12, p=.34; biceps femoris long head: injured=.97±.13, control=1.02±.09, p=.39; biceps femoris short head: injured=.99±.08, control=1.03±.16, p=.51; total hamstrings volume: injured=.98±.04, control=1.01±.06, p=.31; isometric quadriceps: injured =1.15±.35, control=1.12±.46, p=.89; isometric hamstrings: injured= 1.14±.46, control=1.05±.54, p=.72; concentric quadriceps: injured= 1.12±.47, control=1.07±.25, p=.74; concentric hamstrings: injured= 1.04±.27, control=1.00±.18, p=.68; eccentric quadriceps: injured= .88±.22, control=1.07±.48, p=.32; eccentric hamstrings: injured= .95±.20, control=.90±.23, p=.60; 90/90 test: injured=1.03±.08, control= 1.0±.07, p=.38; isometric quadriceps: injured=1.15±.35, control=1.12±.46, p=.89; Thomas test-thigh: injured= .58±.83, control=1.69±.2.42, p=.26; Thomas test-shank: injured=.88±.28, control=.89±..24, p=.94). **Conclusions:** Quadriceps volume was decreased by approximately 4% on the involved limb in sprinters and jumpers with a history of unilateral hamstring strain; however there were no

symmetry deficits identified in measures of hamstring muscle volume, quadriceps or hamstring strength, or flexibility. The diminished quadriceps volume may represent an adaptive mechanism acquired post-injury.

A 4-Mile Run Decreases Achilles Tendon Thickness And Cross-Sectional Area In Collegiate Female Cross-Country Runners

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Context: Recently, there has been interest in using ultrasound imaging of tendons and muscles to assess injury and recovery. In runners, the Achilles tendon is the most frequently ruptured tendon. Individuals suffering Achilles tendon rupture are often physically active with high rates of sports participation pre-injury. It is important to understand the effects of running on Achilles tendon thickness to better understand injury risk and to develop training protocols. **Objective:** To investigate acute changes in Achilles tendon thickness and cross-sectional area in female cross-country runners after a 4-mile run compared to age matched non-runners. **Design**: Observational study. **Setting:** Human Performance Research Center. **Participants**: 12 female collegiate cross-country runners (age:19.3±1.5 yrs, height:168.4±4.8 cm, weight: 55.2±4.8 kg) and 7 non-running female volunteers (age:22.1±2.3 yrs, height:167.6±5.6 cm, weight: 67.1 ±13.3 kg). **Intervention**: The Achilles tendon of 12 female collegiate cross-country runners and 7 non-runners were measured 8 cm from the plantar surface of the calcaneus using ultrasound imaging (GE Logic e). Both longitudinal and transverse images were taken before and after a 4-mile training run in the case of the cross country athletes and before and after a 30-minute period in the non-runners. The non-runners refrained from physical activity during the period between measurements. A mark was placed on the skin to ensure the same portion of tendon was measured pre and post-test. The ankle of the runners was maintained at a fixed position of 90 degrees and held in place by a strap attached to a treatment table. The within group change was analyzed using a paired T-test. The between group data were analyzed by MANOVA. The alpha level was set at .05. **Main Outcome Measures**: The dependent variables were the Achilles tendon thickness and cross sectional area at 8 cm superior to the plantar surface of the heel. **Results**: There were significant decreases in tendon thickness of 7.4% ($p<.0001$) and cross-sectional area of 9.6% ($p<.0001$) following the 4-mile run by the cross-country runners. There were no significant decreases in tendon thickness ($p=.470$) and cross-sectional area ($p=.349$) in the non-runners following the 30 minute period of non-exercise. There were significant differences between the runners and non-runners in the change in Achilles tendon thickness ($p=.008$) and cross-sectional area ($p=.004$) between the pre and post measurements. **Conclusions:** There appears to be a thinning of the tendon due to running. It is not known if the magnitude of thinning or lack of thinning or difference in the rate of thinning is associated with the risk of Achilles tendon injury in runners. Further research should be undertaken to investigate correlations between Achilles tendon thickness and the type of workout (e.g. hilly versus flat), foot-strike pattern, and running season (i.e. cross-country versus track) and risk of injury.

Changes In Lower Extremity Biomechanics During Single-Limb Forward Land Following Concussion In Collegiate Football Players

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Context: More than 300,000 sports-related concussions occur annually in the United States. Altered biomechanics observed in gait following concussion may also exist during jump landings, which may increase risk of lower extremity injury. **Objective:** To examine changes in lower extremity biomechanics during a jump landing in football players who sustain a concussion. We hypothesized that kinetics during a jump landing would be negatively altered after concussion. **Design:** Pre-test/post-test study. **Setting:** Testing occurred in the Biomechanics and Motion Analysis Laboratory at the UF&Shands Orthaepedics and Sports Medicine Institute. **Patients or Other Participants:** 13 male Division I football players (age 20.4 ±1.3 years) that sustained a concussion during the competitive season. Interventions: Subjects performed a single-limb forward land on each side during testing sessions before and after the competitive season. Subjects jumped from a 25.4 cm step, landed on a force plate and held their position for 3 seconds. **Main Outcome Measures:** Concussion history was collected from athletic training records. Variables measured during the single-limb forward land included peak vertical ground reaction force (PVGRF), anterior-posterior stability index (APSI, a measure of fluctuations around a 0 point along the sagittal axis of the force plate), time to peak force, and loading rate (PVGRF/time to PVGRF). All variables except for time to peak force were normalized to body weight (BW). Values from the right and left limbs were averaged to obtain one measure per variable, per subject. Paired-samples t-tests were used to determine differences in values of the pre- and post-season measures. Significance level was set at ˜=0.05. Results: Average time from concussion to post-season testing was 75 ± 50.5 days. The APSI showed a significant increase (0.065 ± .004. versus 0.071 ± 0.007; p =0.026) and the time to PVGRF showed a significant decrease (67.5 ± 5.4 ms versus 63.5 ± 6.6 ms; p = 0.005) from pre- to post-season testing. No statistical differences were found between pre- and post-season values in PVGRF (3.5 ± 0.3 BW, 3.5 ± 0.3 BW, respectively; p =0.572) or in loading rate (55.78 ± 7.25 BW/sec, 52.7 ± 5.63 BW/sec, respectively; p=0.179). **Conclusions:** Following concussion Division I collegiate male football players demonstrated an increase in anterior-posterior sway and a decrease in time to PVGRF during a single limb forward land task. These results indicate poor postural stability and reduced time to absorb impact loading, which may increase risk for lower extremity injury. Clinicians may need to incorporate neuromuscular training into concussion rehabilitation protocols.

Comparison Of Trunk And Hip Strength And Flexibility Between Pilots With And Without A Self-Reported History Of Low Back Pain

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Context: Low back pain (LBP) is one of the most common musculoskeletal issues facing military personnel, with a high prevalence reported in helicopter pilots. Although several risk factors (age, history of LBP, total flight-hours, total night-vision goggle flight-hours) have been previously identified, modifiable musculo-skeletal characteristics have not been investigated in this population. Less trunk and hip strength and flexibility have been previously observed in individual with LBP in civilian studies. **Objective**: To compare trunk and hip muscular strength and flexibility in pilots with and without a history of LBP. It was hypothesized that pilots with a history of LBP would exhibit less trunk and hip strength and flexibility than pilots without a history. **Design**: A cross-sectional design. **Setting**: University sports medicine laboratory. **Patients or Other Participants**: A total of 62 pilots with at least 100 flight-hours (previous 12 months), no current LBP, and no physical training restrictions on the day of testing participated in this study. The 31 pilots (aircrafts: AH64=8, UH60=10, CH47=3, OH58=10) with LBP history (29 males/2 females, Age: 31.5±5.9years, HT: 177.1±6.3cm, WT: 84.4±11.3kg, total flight-hours: 1293±1317hrs) were matched on gender, age (±5yrs), and total-flight hours (±500hrs) with pilots (aircrafts: AH64=8, UH60=11, CH47=3,

OH58=9) without LBP history (29 males/2 females, Age: 31.5±5.9years, HT: 176.9±8.8cm, WT: 82.9±14.6kg, total flight-hours: 1291±1312hrs). **Interventions**: An isokinetic dynamometer was used to evaluate isometric hip abduction and isokinetic concentric trunk flexion, extension, and rotation strength. A digital inclinometer was used to measure passive hip internal/external rotation and active lumbar spine flexion/extension, lateral flexion, and rotation flexibility. Paired t-tests or Wilcoxon tests were used to compare between two groups ($p<0.05$). **Main Outcome Measures**: Hip abduction and trunk flexion, extension, and rotation average peak torque were normalized to body weight (%BW). The average of three measures was recorded for hip internal/external rotation and lumbar spine flexion/extension, lateral flexion, and rotation (°). **Results**: The LBP group demonstrated significantly weaker trunk extension strength (LBP: 345.5±78.1%BW, non-LBP: 404.5±66.0%BW, $p=0.004$). The LBP group had significantly less trunk lateral flexion right (LBP: 21.5±4.1°, non-LBP: 26.4±4.6°, $p<0.001$) and left (LBP: 23.0±4.4°, non-LBP: 26.8±4.7°, $p=0.005$) and right rotation flexibility (LBP: 9.4±3.2°, non-LBP: 11.4±3.9°, $p=0.043$). **Conclusions**: The current investigation revealed musculoskeletal characteristics that are associated with pilots with a self-reported history of LBP. For allied health professionals working with a military population, identifying modifiable musculoskeletal characteristics associated with individuals with LBP is essential for treatment and prevention of LBP. Future studies are needed to confirm if these characteristics are predictive of LBP and loss of duty days due to medical leave. Additionally, further research on other modifiable neuromuscular factors (e.g. trunk proprioception, posture, and balance) is warranted. Supported by USAMRMC #W81XWH-11-2-0097

Effects of Arthrogenic Muscle Inhibition On Sagittal Plane Kinetics And Kinematics During Stair Descent

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Context: Arthrogenic muscle inhibition (AMI) is common following knee injury, resulting in decreased quadriceps activation and strength. As a result, performing activities that require increased demand on the quadriceps, such as stair descent, in the presence of AMI may lead to altered lower extremity joint loading and chronic knee injury. The consequences of AMI on joint loading and movement patterns during stair ambulation have not been investigated. **Objective:** Investigate the effects of simulated AMI on knee biomechanics during stair descent. **Setting:** Motion Analysis Research Laboratory. **Design:** Descriptive laboratory study. **Patients or Other Participants:** Eighteen healthy individuals (11M/7F; 22.3±2.4yrs; 174.1±6.8cm; 71.8±8.1kg) participated. Interventions: Participants were outfitted with 26 retroreflective markers and performed three trials of stair descent at a self-selected pace on a custom built staircase instrumented with a force plate. Following baseline testing, 60mL of sterile saline was injected into the knee joint capsule of each participant through an area supralateral to the patella. Ten minutes following effusion, participants performed posttest measurements. Voluntary quadriceps activation was evaluated before and after effusion with the central activation ratio (CAR) using the burst superimposition technique with the knee in 90° of knee flexion to confirm the presence of AMI. **Main Outcome Measures:** Peak internal knee extension moments (KEM), vertical ground reaction force (vGRF) and knee flexion angle (KFA) were

collected through 3-dimensional motion analysis and extracted from the first 50% of stance phase, which was initiated once vGRF exceeded 10N. All variables were averaged across trials with KEM normalized to participant body (mass*height) and vGRF normalized to participant body mass. Dependent t-tests were performed to assess the effects of AMI on peak KEM, vGRF and KFA. Alpha level was set a priori at Pd"0.05. **Results:** The presence of AMI was confirmed with reduction in CAR following effusion (pre: 0.93± 0.07; post: 0.88±0.10; t(17)=2.29, P=0.035). KEM (pre: 0.46±0.17Nm/kgm; post: 0.39±0.13Nm/kgm; t(17)= 2.78, P=0.013) and vGRF (pre: 12.16±1.67N/kg; post: 10.99 ± 1.42N/kg; t(17)=3.62, P=0.002) were significantly lower following effusion while KFA did not change (pre: 24.7± 6.8°; post: 25.9±5.6°; t17=0.842, P=0.412). **Conclusions:** In the presence of AMI, quadriceps activation is decreased and subsequently KEM and vGRF are lower during stair descent. These kinetic changes may be indicative of participants attempting to decrease loading of the effused knee secondary to decreased quadriceps control. Though unexpected, it appears participants were able to overcome quadriceps AMI and avoid potentially hazardous loading of the knee joint. Future investigations may benefit from inclusion of hip and ankle biomechanics to better understand these compensatory strategies. Supported by funding through the Great Lakes Athletic Trainers' Association.

Variability In Clinical Integration Achieved By Athletic Training Students Across Different Clinical Sport Assignments

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Context: Clinical integration, defined as assimilation into the clinical portion of entry-level education, has been shown to impact athletic training students' (ATSs) professional development, motivation and persistence. However, research has yet to elucidate the manner in which different clinical placements can influence clinical integration. **Objective:** Examine differences in the levels of clinical integration achieved by ATSs across various clinical sport assignments. **Design:** Cross-sectional design utilizing a questionnaire for data collection purposes. **Setting:** Thirteen undergraduate Athletic Training Education Programs (ATEPs) in the southeastern United States located at NCAA division I institutions. **Patients or Other Participants:** Questionnaires were administered to 169 ATSs engaged in clinical education experiences. 129 ATSs completed the questionnaire for a response rate of 76.33%. The ATSs had completed an average of 4 ± 2 clinical rotations. Interventions: The 12-item clinical integration scale was developed by the researchers following a review of athletic training and other health professions education literature concerned with clinical education and student retention. The questionnaire was reviewed by a panel of experienced athletic training educators and piloted on a group of 11 recent ATEP graduates. The questionnaire was administered via a combination of in-person and on-line methods. Responses were scored on a 6-point Likert scale (1 strongly disagree-6 strongly agree). Participants completed the 12-item questionnaire, rating clinical integration for each of their previous clinical rotations. Main Outcome Measures: Descriptive statistics, including mean clinical integration scores (potential minimum score of 12, maximum score of 72) were calculated for each clinical placement. One-way analysis of variance (ANOVA) was used to identify differences in clinical integration achieved across clinical placements. **Results:** One-way ANOVA revealed differences in clinical integration levels achieved across various clinical assignments $F(19,415)=3.486$, $p<0.001$. Students completing a rotation with NCAA division I football achieved the lowest levels of clinical integration (46.9±9.1). Other division I sports rated higher with averages ranging from 51.6±10.1 (baseball) to 57.8±4.5 (lacrosse) with less anxiety and time wasting reported than football. The high school rotation rated highly as well (54.7±6.4) with higher levels of learning reported and fewer concerns about anxiety, excessive hours and wasting time. **Conclusions:** There were clear differences in clinical integration achieved among sites. In particular, ATSs completing clinical rotations with NCAA division I football reported the lowest levels of clinical integration. These low levels of integration stemmed from feelings of wasting time during clinical education, completing menial tasks, excessive hours and anxiety associated with the educational experience. As clinical integration is related to student motivation and eventual persistence, matching students to appropriate clinical sites seems as important as matching ATS and preceptor characteristics. Future research should continue to focus on identifying clinical site specific characteristics that not only hinder integration but also those that facilitate integration.

Effects Of Continuing Professional Education On Entry-Level Competence Among Athletic Trainers

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Context: To maintain the ATC® credential athletic trainers (AT) are required to complete mandatory continuing education (CE) within a defined time period because CE is considered vital to insuring clinical competence and preventing outdated practice. Unfortunately, there is a paucity of evidence examining whether the accumulation of CEUs maintains minimal professional competency as determined by the original Board of Certification (BOC) certification process. **Objective:** To determine whether mandatory CE maintains entry-level competence among certified athletic trainers. **Design:** Prospective, cross-sectional, observational study. Setting: AT practice settings. Participants: Convenience sample of 1,025 ATs from a solicitation of 9,789 who re-certified in 2010 and 196 ATs whose certification lapsed (overall response rate was 10.3%). Participants were predominantly female (61%) and Caucasian (91%). Average years practicing as AT was 10.2 years (±7.4); 72% held a masters degree or higher. **Interventions:** An e-mail invitation was sent to ATs recertifying in 2010 and those who allowed their certification to lapse. The invitation explained the research project and asked participants to complete an on-line recertification assessment administered by Castle Worldwide (Raleigh, NC). The recertification assessment was a retired form of the BOC Certification Exam used during 2010-2011 published by Castle Worldwide under the *BOC Role*

Delineation Study 5th Edition. A shortened version of the original 175-item exam, the assessment contained 125 scored, multiple-choice items and not the 50 field test items normally included. Castle conducted a recertification assessment standard setting meeting where nine panelists (ATs) set two passing levels (proficient, advanced) for the recertification assessment. One-way ANOVAs (˜= 0.005 to control experiment-wise error) were performed to investigate between group assessment scores. **Main Outcome Measures:** Inde-pendent variables included highest degree and role. Dependent variables included recertification exam scores, individual domain scores and items considered to be predominantly measuring recall, application, and synthesis. **Results:** Recertification assessment scores ranged from 15-117; mean was 88.6 (±12.7). Converted to percentage correct, the average was 70.9% (range 12%-94%). Twenty-nine percent of ATs completing the assessment passed at the proficient level, 4% at the advanced level. Significant differences ($F_{4,965}$=21.46, P<0.001) existed between ATs with a doctorate (94.92±9.59) and ATs with a Masters in athletic training (92.48±11.28) versus all other educational levels: ATs with a non-AT Masters (88.50±12.51), ATs with a Bachelors-non-AT major (83.25± 14.33), and ATs with a Bachelors-AT major (83.77±11.76). Significant differences ($F_{2,568}$=18.40, P<0.001) existed between educators (97.75± 11.39), practicing ATs (88.62±11.47), and administrators (83.64±15.38). **Conclusions:** Results suggest that many ATs are not maintaining a "proficient" level of competence as measured by this assessment. A paradigm shift may be warranted to address how CE is delivered and measured. Shifting from attendance (seat-time) based CE to improved pre-defined learning outcomes with post-testing and/or assessment of patient outcomes using newly learned skills might be options.

The Relationship Between Candidate Psychological Factors And First-Attempt Pass Rate On The Board Of Certification Examination

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Context: Success on the Board of Certification (BOC) examination is necessary for persons who wish to obtain the Certified Athletic Trainer (ATC) credential. BOC exam first attempt pass rates have historically been an issue in athletic training (AT). **Objective**: The purpose of this study is to examine the impact of coping, locus of control and academic worry on first attempt passing rates of the BOC exam. Study strategies for the BOC exam were also addressed in the study. **Design**: Cross-sectional Survey-based Design. **Setting**: Subjects were recruited through emails sent to CAATE Accredited Entry-Level Program Directors, which were forwarded to recent program graduates who accessed the survey instrument on-line. **Participants**: The research sample consisted of 145 newly graduated AT students, who reported they took the BOC examination from April to October, 2010. **Interventions**: The survey instrument included three sections of items used to measure the elements of locus of control, method of coping and academic worry. Analysis was performed showing the relationships between the scores on these factors and first attempt pass rate on the BOC exam. **Main Outcome Measures**: The dependent variable for this study was the first-attempt pass rate on the BOC exam. Participants were asked to self-report if they passed and how many attempts they had on the BOC exam. Independent variables in the study include coping, locus of control and academic worry. **Results**: Emotion focus coping scores significantly correlate with locus of control (r= -.262, P = .001) and academic worry scores (r= .307, P < .001). Academic worry had a significant relationship with emotion focus coping scores (r= .307, P < .001) and locus of control (r= -.229, P = .006). Locus of control correlated with emotion focus coping (r= -.262, P = .001) and academic worry (r= -.229, P = .006). The results of the logistic regression analysis suggests that the full model significantly predicted passing on the first attempt (˜2 (4) =15.346, p=.004). The results of the t-tests indicate that compared to those who pass the test on the first attempt, those who did not pass on the first attempt had significantly different scores on the Emotion-Focused Coping Scale (p= 0.024), locus of control (p= 0.002), and Academic Worry (p= 0.026). **Conclusions**: Data from this study suggests that psychological factors such as high academic worry, emotion focused coping and an external locus of control have a lower first attempt pass rate on the BOC examination. These data also suggest that students who pass on the first attempt are more likely to use multiple strategies to prepare for the exam. Professional preparation should address psychological issues such as academic worry, locus of control and coping skills along with multiple study strategies and structured preparation activities.

Civic Professionalism: The Impact Of Service Learning On The Professional Development And Values Of First Year Athletic Training Students

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Context: While research supports the value of service learning (SL) in higher education including health care professional preparation programs, research specific to the efficacy of SL in athletic training education is lacking. Furthermore, the value of civic professionalism is discussed in nursing and medicine, yet there has been no such discourse in athletic training. **Objective:** The purpose of this study was to identify ways in which direct service learning influenced the professional development and values of first year athletic training students (ATS) through a framework of civic professionalism. Specifically, research questions included: 1) In what ways do ATS view civic responsibility before and after a direct service learning experience? 2) What specific interactions and/or experiences influence the professional development and values of ATS? 3) In what ways do ATS develop a growing sense of civic professionalism or other professional values? **Design:** Basic qualitative content analysis based on Scholarship of Teaching and Learning methodological framework. **Setting**: Undergraduate athletic training classroom as well as service learning within a community-based free clinic. **Patients or Other Participants:** Undergraduate ATS (sophomore level; n=19) enrolled in A283 – General Medical Issues in Athletic Training were purposively recruited. All of the students, 9 male and 10 females, volunteered to participate. Participant ages ranged from 20-25. **Data Collection and Analysis:** Data collection included reflective group interviews, semi-structured cohort interviews and individual pre, mid and post-service reflective journals. We collected and analyzed data through constant comparative analysis. We also used methodological triangulation, member checks and peer debriefing to ensure trustworthiness. **Results:** Themes such as civic professionalism and social awareness emerged as ATS interacted with patients of various socioeconomic backgrounds and recognized the role they could play to help the community. Direct SL experiences also facilitated professional socialization as interactions with health care professionals reinforced student values and professional behavior. In addition, authentic experiences facilitated self-efficacy in the ATS' developing professional role. Role confusion existed in some instances as roles and responsibilities in the service setting were not consistent with duties of the athletic trainer as students understood them. **Conclusions:** Service learning is beneficial to the development of ATS. Findings suggest Athletic Training Programs (ATP) should emphasize service learning and civic professionalism within their curriculum. ATP may wish to explore different service settings which are more consistent with roles and responsibilities of athletic trainers and/or integrate the value of service learning throughout the ATP curriculum so students more fully appreciate the value of civic professionalism. Further research should also explore perceptions of the community partner, different service learning models, and the value the profession places on community service.

Learning Styles Of Undergraduate Athletic Training Students In A CAATE-Accredited Athletic Training Education Program

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Context: Assessing preferences and perceptions about the athletic training (AT) learning environment may assist program directors to enhance their student's educational experience and overall retention of knowledge. **Objective:** The purpose of this study was to identify and evaluate learning styles of undergraduate AT students and determine if there is a learning style profile that translates into admission acceptance and success on the Board of Certification (BOC) examination for athletic trainers. **Design:** Prospective, cohort. **Setting:** Classroom. **Participants:** Three hundred and fifteen (110M, 205F) college students (18-25yrs.) between 2004-2012 were tested. All students were enrolled (or seeking enrollment) in a CAATE accredited athletic training education program (ATEP) at a mid-sized Division-I institution. **Interventions:** The Kolb Learning Styles Inventory (LSI) is a 12 question survey that describes the way we learn and deal with day-to-day situations. Athletic training interest (ATI) students are administered the LSI as part of their orientation activities annually. Students who are accepted into the ATEP and matriculate through the program repeat the LSI during the Fall semester of their final year. Pass/fail rates from the BOC exam were derived as students completed the ATEP. **Main Outcome Measures:** Concrete experience (CE), active experimentation (AE), reflective observation (RO), and abstract conceptualization (AC) cycles of learning were analyzed and used to compute an overall learning style (accommodator, diverger, converger,

assimilator). Learning styles from the first year were compared to program admission status (yes/no), while learning styles from the final year were compared to success on the BOC exam (pass/fail) using chi-square analysis. **Results:** To determine learning style, combined scores from the cycles of learning are plotted on a grid. Combined learning ability scores (means±SD) for the first year of testing were, AE-RO (7.3±10.8) and AC-CE (2.9±9.9); while those scores in the final year were AE-RO (8.8±10.0) and AC-CE (7.2±10.1). The dominant learning style was an accommodator (31%) for the first year and a converger (39%) for the final year. There was a significant association between learning style and acceptance into the program ($X^2(3, n=281) =12.057, p=0.0072$). The odds of a converger being accepted were 2.44 times higher than any other learning style. There was not a significant association between learning style type and success on the BOC exam ($X^2(3, n=92) =5.525, p=0.137$). **Conclusions:** A converger is defined as a learner who focuses on AE and AC cycles of learning and therefore prefers practical applications of knowledge. As AT students progress in ATEPs, practical applications of their classroom experiences become crucial for achieving success. Enhancing ways to strengthen these students' learning experience in the clinical setting may prepare them more effectively for success in the profession as entry-level athletic trainers. Finally, BOC exam success does not appear to be learning style dependent.

Mental Health Issues in Intercollegiate Athletes: Clinical And Educational Implications

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Context: Currently, limited statistics are available regarding the incidence, recognition and treatment of psychiatric conditions in college student-athletes[1]. A University of Minnesota study[2] indicated that 25.1% of college students had been diagnosed with a mental health condition in their lifetime; therefore, it is probable that student-athletes are experiencing these conditions at similar rates. This study explored what mental health issues certified athletic trainers encountered in student-athletes with whom they work and how the referral process was managed. It also explored whether certified athletic trainers felt their educational background prepared them to manage these conditions. **Design**: An interpretive phenomenological analysis was conducted. **Setting**: Participants were employed in the university setting and currently worked with intercollegiate athletes. **Participants**: Popcorn sampling of 18 certified athletic trainers with a minimum of five years' experience in the intercollegiate setting were interviewed. Eight females and ten males representing all regions of the country and all NCAA divisions participated. Data saturation guided the total number of participants chosen for this study. **Data collection and Analysis**: Semi-structured interviews were conducted and transcribed verbatim. Interview guides were utilized and additional probing questions were posed as concepts emerged. Analysis was conducted using NVivo software. Trustworthiness was established via credibility, transferability, dependability and confirmability through prolonged engagement, persistent observation, member-checking, peer debriefing and an audit trail. **Results**: Positive factors impacting referral were performance declines, personal experiences, knowledge of comorbidity, convenience of Division I resources, cost and convenience of campus counseling centers, confidentiality and supportive coaches' influence. Negative factors which hindered recognition and referral were lack of confidence, coaches' detrimental influence, Division III resources, campus counseling location, confidentiality and emotional impact. Participants encountered mental health issues in their student-athletes ranging from anxiety and depression to substance abuse and disordered eating. Referral resources ranged from team physicians and neuropsychologists to emergency room physicians. Certified athletic trainers felt their educational background did very little to prepare them to recognize and refer mental health issues in their student-athletes, however practical experiences assisted them in gaining this knowledge. **Conclusions**: Educational implications should include incorporation of mental health intervention and referral discussions throughout the curriculum. Speakers such as student-athletes, psychiatrists, psychologists and other mental health professionals should be utilized in relevant courses. Clinically, athletic training staffs should develop contact lists of area mental health professionals and facilities and incorporate a psychosocial component to pre-participation exams. Mental health professionals should be educated on the intricacies of intercollegiate student-athletes and the role of athletic trainers. Staffs should also have in-service training on intervention and referral techniques, as well as setting proper boundaries.

Student Athletes Have Poorer Sleep Compared To Students At The Same University

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Context: Sleep is important for athletes and students and can affect their performance while attending university. However, there is a paucity of information on objective sleep measures in athletes. **Objective:** To compare subjective and objective sleep measures of student athletes and students enrolled at the same university. **Design:** Two groups, repeated measures design. **Setting:** All sleep measurements occurred at each subject's residence. **Participants:** Thirteen healthy students from the university population (5 males and 8 females, height = 171.9 ± 9.1 cm, mass = 69.5 ± 9.2 kg, age = 21.3 ± 1.9 years) and 36 healthy male athletes from the university population (12 hockey players, 24 football players, height = 183.3 ± 5.8cm, mass = 95.2 ± 17.7 kg, age = 21.3 ± 1.9 years) volunteered for this study. **Interventions:** All subjects completed a self report evaluation on sleep including the: SF-12, Pittsburgh Sleep Quality Index (PSQI), Epworth Sleepiness Scale (ESS), and received the Pittsburgh sleep diary and Actiwatch Score (AS). All athletes wore the Actiwatch Score during a 5-day period in the competitive season and students wore the AS during the semester. Both groups completed the sleep diary every night before going to bed and every morning upon awakening recording bed and wake times and subjective sleep information. One-way ANOVA's and paired sample t-tests were used to analyze sleep efficiency (SE), total sleep time (TST), wake after sleep onset (WASO), sleep quality, fatigue upon awakening, and alertness upon awakening (˜=0.05). **Outcome Measures:** Objective sleep measures were calculated from the raw actigraph data and subjective sleep measures were recorded from the diary. **Results:** There was a significant difference between groups for sleep efficiency (SE athletes= 79.3%± 5.9; students= 88.2% ± 3.0; p< .001) and WASO (WASO athletes= 105.9 min ± 36.3; students= 56.2 min ± 17.2; p< .001). There was no change in total sleep time between the athletes and students. In addition, there was a significant difference in bed time variability between football players and students (football players = 74 min± 33min; students= 40min ± 32min; p=.023). Moreover, there was a significant difference in wake time between football players and students (football= 09:18:47 am± 01:07:52; students= 08:00:00 am± 00:45:35; p< .001). In addition, athletes had a higher ESS score compared to students indicating they have more daytime sleepiness (athletes= 7.9±3.6; student= 4.8±2.7; p= .029). **Conclusions**: Athletes have poorer sleep compared to students at the same university. The variability in the athletes' bed time suggests that the full schedule of the student athlete might compromise their ability to get the proper amount of sleep. Considering the amount of resources spent on coaching and conditioning, more studies are needed to address athletes sleep since it could affect performance.

Post-Professional Graduate Students' Perceptions Concerning The Competencies Within The Commission On Accreditation Of Athletic Training Education Programs

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Context: Post-Professional athletic training (PPAT) programs will be implementing six competencies within their programming, which are currently assessed within other healthcare professions. Students' level of ability in these competencies needs to be assessed. **Objective:** To determine PPAT students' perceived abilities, importance, and preparedness to implement concepts of the six educational competencies within their clinical practice. **Design:** Cross-sectional design. **Setting:** Self-reported paper survey. **Participants:** 202 of 258 PPAT students (78.29%) completed the survey (74 males, 128 females, age=23.32±2.10yrs). Participants included 95 first-year students, 91 second-year students, and 16 students from a one-year program.**Interventions:** Participants completed the survey in the Fall of 2012. The survey consisted of three sections for each identified educational competency: quality improvement(QI), professionalism (PROF), healthcare informatics(HCI), interdisciplinary collaboration(IDC), evidence-based practice(EBP), and patient-centered care(PCC). Three scales were used for each competency: 1) participants rated their ability to incorporate concepts of each competency within clinical practice, 2) participants identified how important they perceived each concept to be for implementation within their clinical practice, and 3) participants reported how well they perceived their professional undergraduate athletic

training program (ATEP) had prepared them for each concept. Each concept described an ability that was related to the definition of the competency. Reliability for each scale was found to be extremely high: $\tilde{}_{ability}$=.955, $\tilde{}_{importance}$=.967, $\tilde{}_{preparedness}$=.971. **Main Outcomes Measures:** The survey consisted of Likert-scale items(range 1-4) and the number of concept statements ranged from 8-18 for each competency. Composite ability, importance, and preparedness Likert-scale scores were achieved by tabulating all values and then averaging the scores back to the Likert scale. Higher scores indicated that participants perceived themselves to have greater ability, that the concepts were more important for implementation in clinical practice, and that they perceived themselves to be more prepared. Descriptive statistics (means, standard deviations, percentages) were reported and between-group differences were calculated using Mann-Whitney U tests (P<.05). **Results:** Overall, participants reported they "agree" they were able to implement the concepts of the competencies into their daily practice (QI=3.28/4.0±0.32, PROF= 3.46/4.0±0.29, HCI=2.92/4.0±0.43, IDC=3.15/4.0±0.44, EBP=3.32/ 4.0±0.35, and PCC=3.20/4.0±0.37), and perceived the concepts involved in the QI(3.66/4.0±0.29), PROF(3.75/ 4.0±0.28), HCI(3.41/4.0±0.44), IDC(3.65/4.0±0.34), EBP(3.64/ 4.0±0.36), and PCC(3.61/4.0±0.36) competencies to be "moderately important" to "extremely important" for implementation. While they perceived their professional ATEPs "moderately prepared" them for the QI(3.18/4.0±0.41), PROF(3.36/ 4.0±0.39), IDC(3.13/4.0±0.53), EBP(3.18/4.0±0.49), and PCC(3.14/ 4.0±0.49) competencies, 57% of participants reported they felt "minimally prepared" regarding HCI. Second-year students perceived themselves to have greater ability regarding the PROF($M_{1styear}$=3.41/ 4.0±0.29, $M_{2ndyear}$=3.53/4.0±0.27, U=3331, p=.007) and EBP ($M_{1styear}$=3.26/4.0±0.31, $M_{2ndyear}$=3.40/ 4.0±0.37, U=3244, p=.006) competencies than first-year students. **Conclusions:** Although PPAT students are implementing the six competencies within their clinical practice, improvement occurs while enrolled in PPAT programs. Further research is needed to determine which factors affect changes in competency improvement within professional and post-professional programming.

Perceptions Of Athletic Trainers And Athletic Directors Regarding UIL Anabolic Steroid Testing

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Context: Texas Senate Bill (SB) 8 mandates random anabolic steroid testing of high school athletes to improve athlete health and safety while costing the state $500,000 to 1 million dollars a year. No known research has been conducted on the perceptions of the program by key personnel enforcing the policy. **Objective:** To assess the perceptions of Texas athletic trainers (ATs) and athletic directors (ADs) regarding the purpose, effectiveness, and necessity of the current program. **Design:** Cross sectional survey. **Setting:** An internet-based survey with a six-week window and a 2-week and 4-week invitation reminder. **Participants:** We randomly selected 900 ATs and 1,020 ADs to participate. ATs were all certified or associate members of D6 employed in high school or clinic outreach settings. ADs were identified from the 2011-2012 Texas Sports Guide of High Schools and Colleges. **Interventions:** A survey with 24 Likert-style and 8 demographic questions was developed with 2 content-matter experts (an expert in health legislation and a researcher of anabolic steroid use among adolescents). Three ATs and three ADs were interviewed to assess face validity. The survey addressed perceptions in four areas: 1.) purpose of mandatory anabolic steroid testing, 2.) effectiveness of mandatory anabolic steroid testing and anabolic steroid education programs, 3.) necessity of state regulated mandatory anabolic steroid testing, and 4.) knowledge of Senate Bill 8. **Main Outcome Measures:** Dependent variables were the endorsements for the questions, which were classified as

endorsed when the participant selected a rating of "agree" or "strongly agree". **Results:** 140 (15.6% response rate) ATs (87 males, 53 females) and 187 (18.3% response rate) ADs (178 males, 9 females) responded to the survey. ADs were fairly distributed throughout Texas geographic locations and school sizes. ATs were fairly distributed throughout Texas geographic locations, however most respondents were employed at a 3A or larger school. A small number of ATs (21.5%) and ADs (31.6%) believe that anabolic steroid testing, in general, is effective. A smaller number of ATs (19.3%) and ADs (28.6%) believed that Texas mandated anabolic steroid testing prevents anabolic steroid use among high school athletes. A greater number of ATs (49.3%) and ADs (65.6%) believed adult led education programs were effective in deterring anabolic steroid use. Only a small number of ATs (3.6%) and ADs (2.7%) believe that the Texas Legislature should be responsible for regulating testing or education programs in high school athletics. **Conclusions:** ATs and ADs perceive that anabolic steroid education programs are a more effective deterrent than random anabolic steroid testing and recent research evidence concurs with their perceptions. Given recent research findings and ATs/ADs perceptions, SB 8 should be re-evaluated. Changes could increase the practicality and effectiveness of a steroid prevention program by redirecting funding to evidence-based steroid education programs.

Graded Talocrural Joint Mobilization Does Not Alter Cortical Motor Excitability Of The Soleus In Individuals With Chronic Ankle Instability

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Context: Ankle joint mobilization can influence lower extremity spinal reflex excitability in individuals with chronic ankle instability (CAI). It is possible that changes in cortical motor excitability occur in conjunction with changes in spinal reflex excitability. It is unknown if a higher intensity joint manipulation (Grade V) has a more profound effect at altering cortical motor excitability than a lower intensity mobilizations (Grade IV). **Objective**: To determine the effects of talocrural joint manipulation or mobilization on cortical motor excitability of the soleus in individuals with CAI. We hypothesize that the Grade V mobilization will result in a greater increase in cortical motor excitability than the Grade IV mobilization and there will be no change following a sham intervention. **Design:** Randomized crossover design. **Setting:** University research laboratory. **Patients or Other Participants:** Twenty-eight participants (age=22.7±2.9 y, height= 173.9±9.1 cm, mass= 72.6±14.0 kg) volunteered for this study. All participants had CAI which was defined as repetitive episodes of instability and quantified by scoring less than 85% on the Foot and Ankle Mobility Measure Sport subscale or at least 3 on the Ankle Instability Instrument. Participants also demonstrated at least a 5° deficit in ankle dorsiflexion compared to the contralateral ankle. **Interventions:** Participants received each of the following interventions, in a randomized order, with at least 48 hours between testing sessions; talocrural joint manipulation (Grade V; maximum of 2 attempts), talocrural joint anterior to posterior mobilization (Grade IV; 3 sets, 60 oscillations), and a sham intervention (positioning similar to Grade IV). Cortical motor excitability of the soleus was determined by measuring the amplitude of a motor evoked potential (MEP) following transcranial magnetic stimulation. The intensity was set at 120% active motor threshold with five MEPs obtained. Maximal muscle response (M_{max}) was determined by delivering a percutaneous electrical stimulus, with incremental increasing intensity, to the tibial nerve and measuring the maximal peak-to-peak amplitude of the muscle response with three measures obtained. **Main Outcome Measures:** The average peak-to-peak amplitude of the MEP normalized to M_{max} (MEP/M_{max} ratio) and expressed as a percentage was used for data analysis. A two-way mixed model ANOVA was used to compare changes in soleus MEP/M_{max} ratio between interventions over time (pre/post intervention). **Results:** There were no significant differences between groups when examining changes in soleus MEP/M_{max} ratio ($F_{2,58}$=0.16, *P*= .86) (Grade V Pre= 2.71±1.10%, Post= 2.64±1.34%; Grade IV Pre= 2.83±1.37%, Post= 2.52±0.98%; Sham Pre= 2.65±1.19%, Post= 2.44±0.94%). **Conclusions**: Talocrural joint mobilization (Grade V and IV) did not alter cortical motor excitability of the soleus individuals with CAI. Although talocrural joint mobilization has previously been reported to improve outcomes associated with CAI, the mechanism of effectiveness may not involve changes in cortical motor excitability.

Shoulder Kinematics In Elite Volleyball Players Following A Full Season Of Play

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Context: Changes to the shoulder complex, such as postural impairment, muscle length and scapular dyskinesis, have been associated with shoulder injuries in overhead athletes. It is unknown if changes in scapular kinematics are normal as a result of participating in a full season of an overhead sport regardless of the presence of shoulder injury. **Objective:** To compare pre-season and post-season scapular upward rotation (SUR), anterior scapular position (ASP), glenohumeral internal rotation (IR) and glenohumeral external rotation (ER) in elite volleyball players. **Design:** Within subject. **Setting:** Controlled laboratory. **Patients or Other Participants:** Sixteen female collegiate volleyball athletes were recruited. Fourteen (18.9±1.1 y, 174.9±5.8 cm, 70.7±10.2 kg) completed a full volleyball season and were included in the study. **Interventions:** Static SUR was measured at rest, 60ˆ, 90 and 120 of humeral elevation in the scapular plane with an electrical inclinometer. Anterior scapular position was measured using the pectoralis minor length test. With the participant in a supine position, the distance in centimeters from the table to the posterior aspect of the acromion process was measured with a modified triangle. For IR and ER, participants laid in a supine position with the shoulder abducted to 90 and the elbow flexed to 90ˆ. Maximum passive IR and ER were measured with a digital protractor placed in-line with the olecranon process and ulnar styloid process. For each kinematic assessment, three trials were

performed and averaged on the serving dominant arm prior to the start of the pre-season (pretest) and repeated within one week after the final match (posttest). The order of kinematic assessments was randomized. The independent variable was time (pretest and posttest). **Main Outcome Measures:** The dependent variables were the mean measurements for SUR at rest, 60ˆ, 90 and 120ˆ, ASP, IR and ER. The influence of time for each dependent variable was compared using paired samples t-tests with an adjusted alpha level ($p<0.007$). **Results:** There were no significant differences for SUR at rest (t_{13}=0.270; P=0.791) within the pretest (3.1±3.9°) and posttest (2.9±3.9°), 60 (t_{13}=-1.326; P= 0.208) within the pretest (9.1±3.6°) and posttest (10.3±4.9°), 90 (t_{13}=-1.426; P=0.177) within the pretest (22.1±4.6°) and posttest (23.8±4.4°) and 120ˆ (t_{13}=-0.859; P=0.406) within the pretest (36.7±6.8°) and posttest (37.9±5.0°). There were no significant differences for ASP (t_{13}=1.760; P=0.102) within the pretest (5.8±1.1cm) and posttest (5.5±1.3cm), IR (t_{13}=-1.117; P=0.284) within the pretest (67.3±8.2°) and posttest (69.1±10.9°) and ER (t_{13}=-1.921; P=0.077) within the pretest (136.1±10.7°) and posttest (139.7±9.1°). **Conclusions:** Participation in a full volleyball season does not appear to change SUR, ASP, IR and ER in elite volleyball players. Clinicians should consider these results when comparing physical exam findings before, during and after a season. Future research should investigate the shoulder kinematics of overhead athletes over the course of multiple seasons.

Effectiveness Of Three-Sanitation Techniques On Bacterial Growth On Athletic Mouthguards After Activity

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Context: Observations during sporting events suggest that athletic mouthguards (device) are commonly dropped in the dirt/mud, stored improperly in dark, warm environments, and placed in areas on the body and equipment that are unhygienic. These potentially "dirty" devices are then placed directly back into the athlete's mouth. **Objective:** Determine the degree of contamination on athletic mouthguards after routine use, and to evaluate the efficacy of three different disinfecting methods in reducing bacterial exposure to collegiate athletes. **Design:** Cross-sectional, repeated measures. **Setting:** Football practice setting and microbiology laboratory. **Participants**: A convenience sample of 30 collegiate male football players (age=20.4±1.4; height =187.6 cm±9.5cm; mass= 109.2kg±21.9) free of recent history of oral/dental trauma. **Interventions:** The study consisted of four phases. Phase-1, participants fabricated a "boil and bite" mouthguard following manufacture recommendations, and then wore the device for one 2 1/2 hour practice. Phase-2, devices were collected post-practice, placed in labeled, quart-plastic bags (preventing cross contamination), and delivered to the microbiology lab. The devices were aseptically swabbed and planted on sheep blood agar (SBA) plates, and incubated at 37ˆC for 24 hours. Devices were returned to the plastic bag, placed in a "sports" bag, and stored at 23°C for 24 hours. After 24 hours, the devices were again swabbed, planted (SBA), and incubated for 24 hours to begin phase-3. The devices were randomized and disinfected using one of three treatments (dish detergent/cold water, Colgate Total® toothpaste, UVC-light). The disinfected devices were swabbed, planted (SBA), and incubated for 24 hours. In phase-4, the two sets of 30 plates were evaluated for colony counts and appearance. The independent variable was treatment group. Bacterial colony growth and count were dependent variables. **Main Outcome Measures:** Colony growths too numerous to count (TNTC) were defaulted to the minimal threshold level of 300. Data was analyzed with descriptive statistics, and a repeated measures ANOVA (group X time [initial, post-24, post-disinfected swab]) set *a priori* at 0.05 using SPSS 20.0 **Results:** A repeated measures ANOVA revealed a significant main effect for time ($F_{2,54}$=23.8, $P < 0.001$) on normal mouth flora colony counts. All groups decreased bacterial growth from initial swab (260.0±103.7), to post-24 (168.3±139.2), to post-disinfected (100.8±110.4). Results revealed no significant interaction or group main effect. In post-disinfected swabbings, 100% of toothpaste, 81.8% dish detergent/cold water, and 77.8% UVC-light had growth. Majority of organisms were normal flora; however, opportunistic bacteria accounted for 50%, 33.3%, and 18.2% of the growth in the toothpaste, UVC-light, and dish detergent/cold water treatment groups, respectively. **Conclusions:** If un-sanitized, mouthguards may be a possible vector for bacterial growth. Of the three interventions, dish detergent/cold water appeared to be the more effective in reducing the opportunistic bacterial growth. However, more research is warranted on a larger sample size.

Prevalence Of Staphylococcus Aureus And MRSA In And Around A Therapeutic Whirlpool In College Athletic Training Room

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Context: Community-associated methicillin resistant *Staphylococcus aureus* (CA-MRSA) has become a leading cause of skin and soft tissue infection in the non-hospitalized community. Care for the athletes in athletic training rooms (ATR) is specifically designed with equipment tailored to the health care needs of the athletes; yet recent studies indicate that CA-MRSA is still prevalent in athletic facilities and that cleaning methods may not be optimal. **Objective:** To assess *Staphylococcus aureus* and CA-MRSA prevalence in and around whirlpools in the ATR. **Design:** Observation. **Setting:** Division I Midwestern University. **Parti-cipants:** Student-athletes (n=109) consisting of 46 men (42%) and 63 women (58%) from 6 sports, participated in the study. **Main Outcome Measures:** The study assessed the presence of MRSA and *Staphylococcus aureus* in and around the whirlpool structures relative to the sports and number of athletes using the whirlpools. **Results:** We identified *Staphylococcus aureus* in 22% (n=52/240) of the samples and MRSA in 0.8% (n=2/240) samples. Thirteen (22%) samples tested positive for *Staphylococcus aureus* in the opening shift, seven (11%) from the pre-practice shift, and 32 (28%) from the post-practice shift. Two (1.7%) samples tested positive for CA-MRSA in the post-practice shift from the drain and water. Over the course of 15 days, we identified *Staphylococcus aureus* from drains on two days (13%), from the agitator head and turbine switch on one day (7%), from the wood steps on 11 days (73%), from the neoprene toe caps on 13 days (87%), from the water on eight days (53%). We also identified *Staphylococcus aureus* from drain and water on two of the days (13%). A statistically significant difference existed between the number of athletes using the whirlpool and the presence of *Staphylococcus aureus* in and around the whirlpools ($F_{2,238}$=2.445, p=0.007). However, *Staphylococcus aureus* was identified regardless of the number of athletes using the whirlpool. We did not identify a significant relationship between the number of athletes whirlpool and *Staphylococcus aureus*/MRSA density (p=0.134). **Conclusions:** The identification of *Staphylococcus aureus* and MRSA throughout the day and 24 hours after closing cleaning procedures suggests whirlpools and related structures should be cleaned and disinfected regardless of number of athletes using a whirlpool and on a routine basis throughout the day. According to CDC guidelines for environmental infection control in health care facilities-hydrotherapy tanks and pools, draining and cleaning of the whirlpool after each patient's use with EPA-registered products are recommended. However, draining and cleaning of whirlpools after each patient did not occur during data collection, nor is it traditional practice in a collegiate ATR. Transmission of the bacteria can be reduced by following the Center for Disease Control and Prevention recommended cleaning and disinfecting protocols. Athletic Trainers should use registered disinfectants to sanitize sanitation all whirlpools between uses. **Key Words:** Cleaning, Center for Disease Control and Prevention Recommendations, Sanitizing, Infection

Using Implement Soft Tissue Mobilization Technique And Laser To Treat Lateral Epicondylitis

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Background: A 42 year old female surgical technology student complained of pain in her elbow after completing surgical technology externship. Patient spent 6-10 hours per day gripping instruments for surgery. The patient reported pain over left lateral epicondyle and no neurological symptoms in the hand or forearm. Palpation over lateral epicondyle increased pain as well as resisted wrist extension and ulnar deviation. Grip strength was 20 pounds for the left hand and 40 pounds for the right hand; pinch strength was 25 pounds bilaterally. **Differential Diagnosis:** Lateral epicondylitis, wrist extensor strain. Treatment: Physician diagnosed patient with lateral epicondylitis. During the initial treatment (8/7/2012) the patient's forearm and elbow were heated with an electric heating pad set at 126o F for 10 minutes. After heating the patient receive Implement Soft Tissue Mobilization Technique (IASTM) treatment using three instruments for 10 minutes over the flexor and extensor muscle groups and tendons, pronator terres, and around the right elbow. Four strokes were used including sweeping and fanning the area to detect and treat fascial restrictions, framing around the boney structures and light brushing was used over the lateral epicondyle to decrease pain. Fascial restrictions were mainly found in the flexor muscle group and pronator terres. After the treatment, the patient completed wrist flexion and extension stretches 3 x 30 seconds with arm fully extended. The patient was then treated with Laser-stimulation set at super pulsed 25 W laser (905 nm) 5-1000 Hz, 4 Infrared (660nm),

for 5 minutes over the lateral epicondyle and forearm and 50 Hz for 5 minutes over the cubital fossa to increase blood flow to the elbow. The patient was instructed to perform wrist flexion and extension stretches at home and ice as needed. During the second visit, two weeks later (8/23/2012), the patient reported pain had decreased for 2 days after the first treatment, but had returned. The second treatment was the same as the first heat, IASTM technique and stretching, however, the Laser treatment was changed. The Laser treatment utilized the LASER Shower consisting of six 50W Laser diodes (905 nm) and four 25W Infrared diode (660nm)and the settings were 5-250 Hz (anti-inflammatory effects) for 5 minutes over the lateral epicondyle and 50 Hz for 5 minutes over the cubital fossa. The patient report her pain had decreased when she left the clinic. Upon arriving at her third treatment (8/28/2012), the patient reported pain was only a 3/10. The patient received the same treatment as last visit, and added 50 repetitions of the following exercises, wrist flexion and extension with 2 pounds and supination and pronation with a green flex bar. An addition laser treatment to decrease pain was added (1000 Hz for 5 minutes over the C5-C6 nerve root). The patient was iced using a commercial ice pack for 10 minutes post exercise. The patient reported that she was pain free when she left. The patient came to her last visit on 8/30/2012 and reported her elbow was pain free. She was treated with heat, wrist flexion and extension stretches, exercises, and laser treatment as described for the previous visit. The patient self discharged at the end of the visit, therefore final grip strength measures were not obtained. Uniqueness: Patient was pain free after only three treatments utilizing the combination of IASTM and laser treatments. **Conclusions:** The combination of IASTM and Laser are effective in treating lateral epicondylitis.

Clinical Outcomes Of Platelet Rich Plasma Injection In Patients With Patellar Tendinopathy Following ACL Reconstruction

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Context: Anterior Cruciate Ligament (ACL) reconstruction utilizing a patellar tendon autograft can cause Patellar Tendinopathy (PT) in patients, leading to decreased function, inability to return to prior levels of activity, and reduced patient satisfaction post-operatively. In situations where conservative treatment has not provided pain relief, platelet-rich plasma (PRP) injection has been proposed as an additional treatment to help augment patellar tendon healing to alleviate pain and improve function. To date, little data exists that documents changes in knee function following PRP injection for PT following ACL reconstruction. **Objective:** Document changes in self-reported knee pain and function for patients treated with single intratendinous PRP injection for PT following ACL reconstruction. Design: Prospective case series. **Setting:** Sports medicine clinic. **Patients or Other Participants:** Eleven patients (9 females, 2 males; average age = 19 ± 2.19 years) with chronic PT recalcitrant to multiple conservative treatments (physical therapy, NSAIDS, rest, iontophoresis) following an ACL reconstruction utilizing a patellar tendon autograft. Interventions: Each patient was diagnosed with PT and received an intratendinous PRP injection of the proximal patellar tendon. Injections were performed 34.8 ± 17.1 weeks post-ACL reconstruction. Each patient completed the 2000 International Knee Documentation Committee (IKDC) at pre-injection and at 29.5 ± 17.7 weeks post-PRP injection. **Main Outcome Measures:** The primary outcome variable was the paired differences of IKDC scores (pre-injection to post-injection) for each patient assessed with the Wilcoxon Signed-Rank Test (pd”0.05) and reported as the median (inter-quartile ranges [IQR]: 25th and 75th). A difference of 12 points in an individual subject’s IKDC score indicates a significant change. **Results:** IKDC pre-injection values were (48.3 [44.3, 60.3) while post-injection values were (74.7 [52.9, 82.8]). The post-injection scores were significantly higher (13.8 [1.1, 33.0]) (p = 0.02). Seven (64%) patients showed significant improvement in their IKDC scores, while four (36%) patients showed no significant change. **Conclusions:** PRP injection may be a viable treatment option for patients with PT following ACL reconstruction with a patellar tendon autograft.

Osteo Chondral Defect Successfully Treated With LASER

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Background: A forty year old female house wife presented to the free rehabilitation clinic complaining right anterior medial knee pain. The patient was unable to determine mechanism of injury. Pain started one month prior to evaluation and increased with stair climbing and washing the floors. The patient wore a compression wrap for 1 month prior to appointment, but it did not help. Pain level was 7/10 during the initial evaluation. Palpation: Tenderness was noted anterior and medial knee and thigh around the VMO insertion and medial femoral condyle. Observation: No swelling in knee was observed. Knee Active Range Of Motion was within normal limits. Resisted range motion – Right knee Flexion 4/5 pain; Extension- 4/5 pain, Left knee Flexion 5/5, extension 5/5. The following ligamentous tests were negative: Lachman's; Posterior Drawer; and Varus/ Valgus. Wilsons test for osterchondral defects of the knee was positive and Thessaly's test for a meniscus tear was negative. **Differential Diagnosis:** Osteo Chondral Defect; Subchondral Cyst. **Treatment:** X-Ray impressions were a subchondral cyst versus osteochondral defect medial femoral condyle; physician diagnosed as osteochondral defect. The patient was treated four times with low level laser over a 5 week period. The low level laser used a LASER Shower consisting of six 50W Laser diodes (905 nm) and four 25W Infrared diode (660nm). Each day the patient was seated on edge of treatment table with her knee bent to 90o of flexion. She received a 5 minute treatment at 5-1000 Hz over the medial condyle and a 5 minute 50 Hz treatment over the popliteal fossa to increase blood flow to the knee. Treatment 1 (7-10-12) Laser treatment plus commercial ice pack for 10'; Treatment 2 (7-17-12) Patient reported her knee felt better for 2-3 days after initial laser treatment. However, the patient reported she re-injured her knee closing a door on 7-16-12. Pain was great enough to have the knee buckle (9/10). The patient reported a pain decreased immediately after laser treatment (6/10). Treatment 3 (8-7-12) The patient reported she only had pain in the knee when she was not wearing the compression wrap, otherwise pain 0/10. Palpation of medial condyle did not elicit pain. Treatment 4 (8-14-12) The patient reported knee Pain 0/10 even without knee wrap. She stated that there was a slight ache. Immediately after the laser treatment the patient reported no pain or ache in the knee. The patient reported she was able to perform all activities of daily living without knee wrapped. Wilson's test was negative and knee flexion and extension strength was 5/5 bi-laterally. The patient discharged herself at this time. **Uniqueness:** Pain level decreased significantly after one laser treatment and was completely alleviated with just four laser treatments over five weeks. Ice was applied during the initial visit, but not thereafter. **Conclusions:** LASER is a viable non-invasive treatment to reduce pain and increase function in patients with an osteo chondral defect.

Deep And Superficial Quadriceps Heating Using Continuous Shortwave Diathermy At Two Different Duty Cycles

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Context: Shortwave diathermy (SWD) has traditionally been delivered via a drum and large machine; however, new technology uses circumferential sleeves and portable units to deliver energy. SWD is used for heating deep tissue for pain relief, spasm reduction, and/or improvement in tissue compliance; however, we still lack data regarding the relationship of intensity and duration to treatment outcomes. **Objective:** To investigate the heating of two continuous SWD (50% and 100%) settings on both superficial and deep tissue heating. **Design:** Within repeated measure crossover design. **Setting:** Controlled laboratory setting. **Participants:** Twenty-five males (n=14) and females (n=11) (age = 25±5 years, mass = 80±16 kg, height = 174± 9cm, distal thigh skinfold = 15.8±9mm) volunteered for study. All had no current injury involving their thighs or knees. Interventions: Thermocouples were inserted into both distal and proximal vastus lateralis muscles using a 1.16 in and 1.88in 20g catheter needle, respectively. The proximal thermocouple was inserted to an absolute depth of ~4 cm from the skin surface (4.0±0.1cm) and the distal thermocouple was inserted 1.5 cm below the subcutaneous adipose layer (~2.3±0.4cm depth). The thermocouple was interfaced through an Isothermex®. Two counterbalanced conditions using theRebound™ continuous shortwave diathermy (CSWD) unit were compared including (1) 50% duty cycle/35 minutes and (2) 100% duty cycle/35 minutes. The CSWD was delivered at 13.1 MHz using standard thigh sleeve. **Main Outcome Measures:** Baseline

(TB), skin surface (TSKIN), superficial and deep intramuscular (SupTIM; DeepTIM) temperatures (°C). Two separate 2 x 11 (condition x time) repeated measures ANOVAs with eleven levels of time (Start, 5, 10, 15, 20, 25, 30, 35, post5, post10, post15 minutes) investigated changes in skin surface and both SupTIM and DeepTIM. Alpha wasset apriori at 0.05. **Results:** There was no difference ($p>0.05$) in TB at each temperature site between conditions (Skin: 32.1±0.2°C; Superficial: 35±0.1°C; Deep:36.6 ±0.1°C). There was a condition x time interaction for TSKIN ($p<0.001$) and SupTIM ($p<0.001$), but no interaction or main effect for DeepTIM. Both TSKIN and SupTIM increased significantlyover treatment time. The 95% CIs were 38.3-38.9°C (Skin), 38.3-38.8°C (SupTIM), 37.2-37.8°C (Deep TIM) after 35 minutes of treatment using 100% duty cycle. The 95% CIswere 36.5-37.2°C (Skin), 36.8-37.4°C (SupTIM), 36.9-37.3°C (Deep TIM) after 35 minutes of treatment using 50% duty cycle. **Conclusions:** Intensity of energy does determine amount of heat transfer and overall tissue heating when using CSWD. Both 50% and 100% settings were effective in heating skin and the superficial muscle above baseline levels as early as 5 minutes after treatment began. Therapeutic levels of heating wereachieved at both skin surface and superficial muscle sites as increases greater 1°Cwere seen at these sites across both duty cycles.

Effects Of Applied Pressure On Intramuscular Temperature During Ultrasound Treatments

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Context: The magnitude of intramuscular temperature increase during therapeutic ultrasound is dependent upon depth, frequency, and intensity. These variables have been studied widely. Another potential variable that could affect the rate of temperature elevation is the pressure that is applied to the transducer head during application. Added pressure could compress the tissue affecting density and the transmission of ultrasound energy. Little research has been completed to determine the effects of the amount of pressure applied during therapeutic ultrasound. **Objective**: To determine the effects of different applied transducer pressures on intramuscular temperature during an ultrasound treatment within the left triceps surae. **Design**: Crossover Clinical Trial. **Setting**: Human Performance Research Laboratory. **Participants**: Convenience sample of thirteen healthy, college-aged students (M=5, F=7, Height: 170.03±9.86 cm, Mass: 71.96±16.2 kg, Skinfold: 12.79±5.5 mm, Calf circumference: 35.5±6.9 cm) free of lower leg injury for the previous six months and no known contraindications to ultrasound volunteered to participate. **Interventions**: Three separate 3MHz, 1.0W/cm^2 ultrasound treatments were administered to the triceps surae, using weights on the transducer head of: 200 g, 600 g and 800 g. Treatments were within subjects and order was counter-balanced. The independent variable was pressure applied by the transducer head. The dependent variable was time required to raise temperature 0.5, 1.0, 1.5 and 2°C at a depth of 1.5 cm below the surface of the skin. **Main Outcome Measures**: Intramuscular temperature probes were used to measure triceps surae temperature and the time required to increase temperature to the four temperature intervals was determined. A two within repeated measures analysis of variance (RM-ANOVA) was used to analyze the differences in time for each pressure (200 g, 600 g, and 800 g) that it took to reach critical temperature points (baseline, 0.5°C, 1.0°C, 1.5°C and 2.0°C). **Results:** There was no significant interaction between time and pressure ($F(8,96)=1.494$, $P=.169$). The time required to raise temperature 2°C was 209.1± 104.3s with 200 g, 181.5± 123.7s with 600 g, and 194.9± 90.9s with 800 g. **Conclusions:** Under the conditions of this study, the amount of pressure applied with the ultrasound transducer head during an ultrasound treatment does not ultimately affect the rate of tissue heating.

Effect of Lidocaine Phonophoresis With Hydrogel Dressing On Cutaneous Anesthesia After Varying Treatment Times

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Context: Phonophoresis is a therapeutic modality used to treat soft tissue injuries by combining therapeutic ultrasound with a topically applied medication preparation. Application of a thin hydrogel dressing over the topical medication preparation may allow for better medication absorption through the skin. Additionally, alterations in intervention dosage may affect intervention efficacy. **Objective:** To determine changes in skin anesthesia on the anterior forearm after 3 different phonophoresis interventions using 2% lidocaine hydrochloride aqueous gel covered with a hydrogel dressing. **Design:** Randomized, double-blind, crossover study. **Setting:** Laboratory. **Patients or Other Participants:** 15 healthy subjects (9 females, 6 males; age: 21.8±2.9 years; height: 170.8±7.2 cm; mass: 72.7±18.2 kg) volunteered to participate. **Interventions:** All subjects received 3 interventions over 3 sessions separated by at least 24 hours. Interventions included continuous phonophoresis: 1 MHz, 1.0 W/cm^2, 5 minutes, continuous duty cycle (100%); pulsed phonophoresis: 1 MHz, 1.0 W/cm^2, 25 minutes, pulsed duty cycle (20%); sham: 0 MHz, 0.0 W/cm^2, 25 minutes. All 3 interventions used 2 cc of 2% lidocaine hydrochloride gel covered with a hydrogel dressing for the duration of intervention. Interventions were randomly assigned, and both the assessor and patient were blinded to intervention order. Clinician 1 marked the treatment area, cleaned the skin, and recorded pre-intervention skin sensation using Semmes-Weinstein Monofilaments (SWM). Clinician 2 administered the assigned intervention before clinician 1 returned to complete follow-up skin sensation measurements at 0-, 15-, and 30-minutes post-intervention. **Main Outcome Measures:** Skin anaesthesia (grams) measured with SWM (larger force values indicate decreased skin sensation). SWM force is presented as mean ± standard deviation. Wilcoxon Signed Ranks tests were used to compare skin anesthesia by group and by time. Results are presented as median (interquartile range). **Results:** Pulsed phonophoresis caused significantly decreased sensation immediately post-intervention [0.70 g (0.41, 1.19), P=.007], 15-minutes post-intervention: [0.70 g (0.41, 1.19), P=.001], and 30-minutes post-intervention: [0.70 g (0.41, 0.70), P=.005] compared to baseline [0.41 g (0.17, 0.70)]. Continuous phonophoresis caused significantly decreased skin sensation immediately post-intervention [0.70 g (0.41, 1.19, P=.011] and 30-minutes post-intervention [0.70 g (0.41, 1.19), P=.027] compared to baseline [.0.41 g (0.17, 0.70)]. Sham phonophoresis caused significantly diminished skin sensation 15-minutes post-intervention [0.70 g (0.41, 1.19, P=.003], and 30-minutes post-intervention [0.70 g (0.41, 1.19), P=.005] compared to baseline [0.41 g (0.17, 0.41)]. **Conclusions:** While all 3 treatments reduced skin sensation post-intervention, there were no significant differences between the 3 interventions at any time point. The continuous motion of the transducer head simulating a massage may be responsible for the reduction in skin sensation. When a clinical application for using phonophoresis is needed to decrease skin sensation, the continuous treatment is more clinically applicable and as effective as the pulsed and sham treatment.

NCAA Division I Soccer Players' Use Of Over-The-Counter Pain Relievers

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Context: Athletes regularly use over-the-counter (OTC) pain relievers in addressing pain. The use of pain relievers by professional soccer players has been studied; however, the prevalence, attitudes, and behaviors related to the use of pain relievers by collegiate soccer players are unknown. **Objective:** To examine the attitudes and behaviors of NCAA Division I collegiate soccer players regarding their use of pain relievers. **Design:** Cross-sectional study. **Setting:** Emailed survey. **Patients or Other Participants:** Fifty-one Division I soccer players from 7 of 16 Summit League Conference teams responded (29%). **Interventions:** Participants completed a 24-item survey with multiple subsets of questions. The survey was a modified version of the "Over-the-Counter Drug Screen for Athletes Survey" (Wolf, 2006) and had a Cronbach's Alpha of 0.699. **Main Outcome Measures:** Frequencies and chi-square (X^2) analyses were used to assess current attitudes, behaviors, and relationships between factors. The main outcome measures included knowledge of drug classifications, knowledge of drug effects, label reading, use of recommended dosage, origin of decision for use, reasons for use, and communication on proper use. **Results:** *Drug classification knowledge* was minimal regarding ibuprofen (41%), naproxen sodium (28%), aspirin (26%), and acetaminophen (22%). *Knowledge of drug effects* was moderate-high regarding use of pain relievers with alcohol (80%), taking higher doses than recommended (78%), and larger athletes requiring higher doses for same effects (65%). *Label reading* was minimally practiced with 21%

reading labels every time pain relievers were used, 28% reading labels before the first use only, and 15% never reading label directions. *Use of recommended dosage* identified 64% using the recommended dose or less, 32% taking more than the recommended dose, and 4% being unaware of recommended doses. A significant correlation (X^2 (4) =11.66, p=0.02) between reading label directions and taking more than the recommended dose was indicated. *Origin of decision for use* revealed self (77%), athletic trainer (11%), parents (9%), and physician/pharmacist (4%) as the determining source. *Reasons for use* indicated sports-related pain (81%), anticipation of pain (66%), and to avoid missing a practice/game (40%). *Communication on proper use* was provided by the athletic trainer every time (53%), sometimes (22%), first time only (19%) and never (6%) when providing the athlete a pain reliever. **Conclusions:** There is evident misuse and lack of knowledge regarding OTC pain relievers and proper usage amongst collegiate soccer players. Based on these results, the health of athletes must be addressed as it pertains to use of OTC pain relievers. It is recommended that educational opportunities be established to inform athletes about the effects and proper usage of OTC pain relievers.

The Use Of Biofeedback In Individuals With Low Back Pain

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Context: Patients with recurrent non-specific low back pain (NSLBP) often have difficulty activating the transversus abdominus (TrA) and multifidus (MF). Patients may benefit from clinician-derived biofeedback including verbal, visual, and tactile cues while performing exercises. **Objective:** To compare TrA and MF preferential activation ratio (PAR) in individuals with NSLBP before and after directed exercises while providing visual, verbal and/or tactile biofeedback. **Design:** Controlled, randomized study **Setting:** Laboratory **Patients or Other Participants:** Twenty, asymptomatic subjects with history of recurrent NSLBP participated (11M/9F, age 23±4 years, height 165.26±12.90 cm, mass 74.74±15.84 kg, current Oswestry low back pain scale=11.35±4.00). **Interventions:** Subjects were randomly allocated to one session of directed exercises with verbal instructions (exercise only: n=10) or verbal instructions while patients observed muscle thickness changes using real-time ultrasound (US) and pressure cuff biofeedback (exercise with biofeedback: n=10). Verbal instructions included cueing to perform a supine abdominal drawing-in maneuver for TrA and lifting the tailbone to the ceiling while prone for a MF contraction. **Main Outcome Measures:** We calculated as the thickness ratio for the TrA relative to the abdominal wall (TrA+external and internal obliques) in the rested and contracted states using real-time ultrasound. We also calculated the thickness ratio of the deep portion of the MF relative to the entire MF in both the contracted and rested states. The PAR was calculated for each muscle as the (contracted ratio – resting rato)/resting ratio. Data were not normally distributed therefore were used Mann-Whitney U tests to compare groups at baseline and after exercise. Wilcoxon-signed ranked tests were used to compare baseline with post-exercise for each group. **Results:** There were no TrA PAR differences between groups at baseline (exercise only 0.02±0.07, exercise with biofeedback 0.06±0.05, p=0.29) or after exercise (exercise 0.08±0.17, exercise with biofeedback 0.12±0.06, p=0.33). The TrA PAR increased pre to post test following exercise with biofeedback (pre 0.06±0.05, post 0.11±0.06, p=0.03), but not after exercise only (pre 0.02±0.07, post 0.08±0.17, p=0.24) There were no MF PAR differences at baseline (exercise 0.06±0.05, exercise with biofeedback 0.10±0.09, p=0.36) or after exercise (exercise 0.09±0.06, exercise with biofeedback 0.09±0.06, p=0.76). There were no changes from baseline to post exercise with biofeedback (pre 0.08±0.07 post 0.09±0.06, p=0.46). **Conclusions:** TrA PAR increased after a session of directed exercises with verbal cueing. The addition of tactile and visual biofeedback techniques did not have an additive effect. MF activation did not improve after a session of directed exercises. Verbal biofeedback may improve TrA contractions in individuals with NSLBP.

Athletes' Attitudes On Treatment Seeking, Injury Reporting, And Severity Of And Playing With Injuries

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Context: Athletes' reporting and seeking treatment for injuries influences the care athletic trainers can provide. Sport ethic and the culture of risk associated with sports may influence these behaviors (Nixon, 1994). **Objective**: The objective of this study was to explore athletes' attitudes related to reporting of and seeking treatment for injuries, on determination of severity of injuries, and on decisions to cease play due to injury. To meet this objective, participants were asked questions in four categories: 1) treatment seeking, 2) injury reporting, 3) injury severity determination, 4) ceasing play. **Design**: Cross-sectional, mixed-methods. **Setting**: NCAA DIII University. **Patients or Other Participants**: Student-athletes in fall/winter sports were recruited as participants; 142 student-athletes (90 men, 52 women; mean age 19.7 years) from soccer, basketball, volleyball, and football provided responses. Thirteen participants reported no previous injury, 79 reported sustaining a minor injury, 56 a moderate injury, and 21 a severe injury (participants may have reported multiple injuries). **Data Collection and Analysis**: Following IRB approval and informed consent, participants provided written responses in a classroom setting during pre-season. Descriptive and inferential statistics were calculated for quantitative items; hierarchical content analyses were conducted for qualitative items. Hierarchical content analyses proceeded through the use of inductive and deductive techniques in order to group meaningful text segments (i.e., quotes) into raw themes, and more general abstract (i.e., higher order) themes through intercoder agreement as described by Mason (2002). **Results**: No statistically significant differences were found between men and women on quantitative items. 1) Do you always seek treatment for your sport injuries? [yes = 103 (72.5%), no = 39 (27.5%)]; themes: optimal performance, injury healing, advice/clearance from medical staff, playing time, injury severity. 2) When injured, do you report the injury to medical staff? [(yes = 125 (88%), no = 17 (12%)]; themes: pain/injury severity, optimal performance. 3) Does the severity of the injury determine if you report it to medical staff? [(yes = 117 (82.4%), no = 23 (16.2%), no report = 2]; themes: pain, optimal performance, previous injury experience. 4) The following themes emerged related to being too injured to play: pain, optimal performance, advice/clearance from medical staff. **Conclusions**: Participants were generally comfortable reporting and seeking treatment for injuries, specifically to athletic trainers. Participants who were reluctant to report or seek treatment identified factors related to playing time. Interestingly, participants based their reporting and their seeking treatment on lack of optimal performance. Based on these findings, athletic trainers should continue to build positive rapport with their athletes, and should take care to educate athletes about pain and injury related to athletic performance. Future investigations should explore psychosocial factors related to injury reporting and treatment seeking, so that strategies can be implemented to enhance athlete care.

Athletic Trainer's Perspectives On Health Care Access Barriers Of Injured/Ill Adolescent Athletes

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Context: The health care access barriers (HCAB) model has been used to identify community factors affecting individual's health care access (financial, structural and cognitive), but little research has been documented on ways to modify health care access barriers and their impacts in adolescent athletes. **Objective:** To understand possible HCABs and their impacts on injured/ill adolescent athletes from the perspectives of athletic trainers. **Design:** Qualitative methodology. Semi-structured focus group interviews were conducted to identify athletic trainer's perspectives and personal experiences with adolescent athletes with HCABs to create a descriptive model. **Setting:** The first focus group took place in a confidential meeting room at the PIs institution while the second and third occurred at a regional athletic training conference. **Patients or Other Participants:** Twenty-two licensed and/or certified Texas athletic trainers (12 males, 10 females; experience = 12.9±9.8 years; range, 3-32 years) with full-time positions employed as an athletic trainer in a middle school or high school and at least 3 years of administrative work experience were purposively sampled to participate in one of three focus group interviews. Focus groups were completed until data saturation occurred. Five athletic trainers (4 males, 1 female; experience = 19±13.1 years; range, 3-32 years) participated in the member-check individual interviews to establish trustworthiness. **Data Collection and Analysis:** Focus group interviews were conducted by the principal investigator face-to-face and were audio-taped and transcribed verbatim. The HCAB model was used to derive

the interview guide questions and we (AH & LV) individually analyzed interviews using a framework analysis. Trustworthiness was established using member checks and analyst triangulation. **Results:** We confirmed the presence and impacts of the 3 barriers, financial, cognitive, and structural, in the HCAB model. Financial barriers were represented by limitations with general insurance, issues with uninsured athletes, and restrictions specific to state/ government/school funded insurance. Structural barriers were problems with transportation, parent availability and communication problems, and healthcare infrastructure constraints. Cognitive barriers related to problems with understanding insurance policies, knowledge about condition/injury and prevention, and language barriers and literacy. A new barrier, sociocultural beliefs and expectations, was discovered from the interviews when problems with obligation beliefs, fear of deportation, and health care system beliefs were noted. All barriers were associated with negative impacts: changes in source of care, time of presentation, quality of care, and prevention. A new modified model, the HCAB-AT model was generated from the findings. **Conclusions:** Our results will help athletic trainers and other health care providers find possible solutions for barriers to minimize the effects of the barriers on athletes and/ or families. Future researchers can examine health care outcomes disparities of adolescent athletes and/ or families and experimentally understand how the impacts can deleteriously affect them.

M1 Macrophages Are Active As Early As Six Hours Following Eccentric Exercise: A Pilot Study

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Context: Recent studies have exposed potential influences of massage at the cellular level however, a lack of sound scientific data to support the efficacy of massage remains. **Objective:** Assess the effects of massage on the temporal inflammatory response following damaging eccentric exercise (EEX). **Design:** Cross-over control study. **Setting:** Performed in a controlled laboratory environment. **Subjects:** Four maleWistar rats, divided into two groups: 6-hour (n=2) and 24-hour (n=2). **Interventions:**Nerve cuff electrodes were surgically implanted on the peroneal nerve of each limb. Animals were provided one-week of recovery time to reduce any confounding inflammatory effects of the surgery. Each limb underwent a single bout of eccentric exercise. Immediately following exercise, the right limb of each animal received a 30- min bout of massage using a customized cyclic compressive loading device (massage memetic). Rats were sacrificed based on respective group time point (i.e. 6hrs or 24hrs). Tibialis Anterior muscles were harvested and cryogenically preserved for tissue analysis. Cells counted using random stereological point counting. **Main OutcomeMeasures:** Identify cellular infiltration of neutrophils, M1, and M2 macrophages utilizing immunohistochemistry techniques. Quantify general cellular infiltration utilizing H&Estaining. **Results:** The most notable result from this pilot investigation was theidentification of M1 macro-phages at 6hrs following EEX and EEX+Massage in all limbs the 6hr group (0.75±0.75 per 0.60mm2 and 5.25± 1.25 per 0.60mm2 respectively). General cellular infiltration measured by H&E was significantly higher in the 6hr compared to the 24hr group (43.0±6.0 and 16.13±2.88 respectively, p=0.04). **Conclusions:** Traditional models of muscle regeneration utilize supra-physiologic means of muscle injury (e.g. freeze injury or cardiotoxin injection). These models have predominantly shaped our view of the time course associated with the inflammatory response. The influx of M1 macrophages has largely been reported to take place at 12hrs post injury, however our pilot data show selective fiber infiltration/ damagemediated by M1ˆs as early as 6hrs. Macrophages are incredibly plastic cells, influenced by the local micro-environment, and have the ability to transition phenotypes between anti- and pro-inflammatory mediators. Our unique in vivo model most closely resembles muscle injury, and allows for the careful temporal analysis of the immune response inregards to various immuno-modulatory treatments like massage. Although small group numbers prevented inferences based on statistical analysis at this time, this observationin genetically identical animals is likely accurate. Therefore, M1 macrophage activation as early as 6hrs following injury, is an important finding that may shape the current dogma associated with macrophage action, the inflammatory response, and growth and regeneration of skeletal muscle.

Acute Response Of High-Intensity And Traditional Resistance Exercise On Anaerobic Power

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Context: Quantifying the maximal work capacity (*W'*) above the aerobic critical power (*CP*) has emerged as a method for estimating anaerobic work capacity. Slower cadence, lower-load resistance training (RT), colloquially referred to as high-intensity training (HIT). HIT consists of slower cadence, lower-load resistance, as commonly used in rehabilitation and reconditioning, and is purported as a better metabolic stressor than faster cadence, higher-load RT. To date this belief has not been substantiated by research. **Objective:** We compared the acute effects of HIT and traditional RT bouts on average power within a 150-second time period ($P_{150\ s}$), *CP* and *W'*, as measured from a 3-minute all-out exercise test using cycling ergometry (3 MT). **Design:** A crossover design was used. **Setting:** Data were collected in a research laboratory. **Patients or Other Participants:** Eight recreationally active males (mean ± *SD*: age 22 ± 2 y, body mass 85 kg ± 14 kg, and height 183 cm ± 9 cm) volunteered. Interventions: Baseline 3 MT, 10 repetition maximum testing on leg-press and leg-extension machines, and post-bout 3 MTs following a HIT (4:2 second cadence) or traditional RT bout (1:1 second cadence) were collected. Previous reported reliability of the 3 MT for *CP* is TE = 15 W, CV = 7%, ICC = 0.93 and for *W'* is TE = 2.8 kJ, CV = 28%, ICC = 0.76, where TE is typical error, CV is coefficient of variation, and ICC is intraclass correlation coefficient. **Main Outcome Measures:** $P_{150\ s}$, *CP*, and *W'* served as the dependent variables and were evaluated using one-way ANOVA with repeated measures (i.e., baseline, post-HIT, and post-traditional RT bouts). Results: Neither HIT (269.2 ± 51.3 W) nor traditional RT (275.1 ± 51.3 W) evoked depreciations ($P > 0.05$) in $P_{150\ s}$ from the baseline (275.1 ± 45.4 W). Moreover, estimates of *W'* at the baseline (8.3 ± 3.2 kJ) were unaffected ($P > 0.05$) either by the HIT (7.6 ± 2.3 kJ) or the traditional RT (8.3 ± 1.3 kJ) bouts. Measures of *CP* were similar pre to post-intervention for HIT (TE = 8.7 W, CV = 4.1%, ICC = 0.96) and traditional RT (TE = 7.2 W, CV = 3.7%, ICC = 0.98), respectively. Anaerobic work capacity, as estimated by *W'*, was more variable for the traditional RT trial (TE = 1.87 kJ, CV = 36.0%, ICC = 0.45) in comparison to the HIT trial (TE = 1.72 kJ, CV = 34.3%, ICC = 0.62). **Conclusions:** These data indicate that the 4:2 cadence is insufficient to exhaust a person's capacity for high-intensity work. Longer RT durations, either by slower cadences or by multiple sets, are necessary to evoke substantive declines on *W'*, and should be investigated.

Feasibility Of Conducting A Web-Based Survey Of Patient Reported Outcomes And Rehabilitation Progress

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Context: Patient reported outcomes(PROs) have become the standard for collecting Health Related Quality of Life data(HRQOL). PROs provide clinicians insight into patients' experiences during treatment. There is currently a need to develop more efficient means to incorporate HRQOL assessments into clinical practice. Collecting surveys on multiple occasions throughout treatment or rehabilitation captures patient perceptions and behaviors throughout the entire treatment process. Web-based surveys provide a means to track data over time more efficiently as they do not rely on the patient returning to the clinic or the use of clinician time for the completion of additional paperwork. **Objective:** Our purpose was to determine the feasibility of utilizing web-based surveys to longitudinally capture compliance and self-reported outcomes among postoperative orthopedic patients. **Setting:** Orthopedic clinic **Design:** Prospective longitudinal cohort. **Patients**: Surgical knee patients were recruited for study participation during their first post-operative clinic visit (n=34, 17 males, 16 females; 34±11.7 years of age). **Interventions**: Following intake questionnaire, patients with internet access, an available email address and willingness to participate in web-based surveys were counter-balanced into groups to receive surveys either every 2 or 4 weeks for 24 weeks post-surgery. Patients were sent a web-link and log-in for each survey via recurring emails. Reminders via email or phone were

provided at regular intervals if surveys were not completed. The surveys included questions related to rehabilitation compliance and attendance and also incorporated questions from the Lysholm Knee Scale, IKDC, and modified Cincinnati Knee Scale. **Main Outcome Measures**: Outcome measures included *recruitment rate* (number of participants consented/number of patients approached for study participation), *eligibility* (participants with available email//participants consented), *willingness* (participants willing to receive web-based surveys/ participants eligible), and *response rate* (percentage of surveys completed by willing participants). Variables were analyzed using frequencies and percentages. Independent t-tests were used to compare response rates between the 2 and 4 week groups. **Results**: Overall 35 patients were approached regarding participation. Recruitment rate was 97%(n=33). Eligibility was 91%(n=30); one patient did not have internet access and 2 did not have email address. Two patients were not willing to participatein surveys (willingness =93%, n=28). The average response rate was 45±36% among all participants. There was no difference in response rates between the 2 week(49±35%) and 4 week groups(42±39%; p=.651). Of all 34 patients that were approached to participate in the study, 47%(16/34) had at least good compliance(≥50% response rate) in the surveys. **Conclusions**: This is one of the first studies to examine the feasibility of web-based surveys in an orthopedic population. Our results demonstrate response rates that are at or above accepted standards for survey research; however, response rates with the current methodology were well below the minimum follow-up rate of 85% recommended for clinical outcomes research.

Hip Kinematics, Strength, And Pain, In Female Runners With Patellofemoral Pain Before And After A Short-Term Intervention

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Context: Patellofemoral Pain (PFP) is associated with abnormal hip kinematics and decreased strength. Nevertheless, few interventions have been developed to simultaneously improve both kinematics and strength. **Objective**: To evaluate the effectiveness of a short-term intervention that focused on muscle awareness exercises and verbal feedback during running to improve hip kinematics, strength, and pain in female runners with PFP. **Design**: A single group, longitudinal study. **Setting**: Laboratory setting. **Participants**: Five female runners with PFP (25.67±6.68 yrs, 1.64±.06 m, 59±11.89 kg) participated. All subjects met inclusion criteria and were used for analysis. Participants had no other injury affecting the lower extremity, nor any previous knee surgeries. PFP was diagnosed by a licensed medical professional using previously established criterion. **Intervention**: Subjects participated in an initial pre-intervention session (Pre), 4 treatment sessions and two post intervention sessions (immediately Post, and 2wks Post). During the initial data collection session, the subjects ran for thirty minutes on an instrumented treadmill. Average peak hip internal rotation (HIR) and hip adduction (HADD) during stance phase were then calculated. During the run, pain was recorded every minute using a 1 to10 pain verbal analog scale (VAS). Hip strength was measured with a hand held dynamometer and recorded as a percentage of torque normalized to body weight * height. Four intervention sessions consisted of performing three specific gluteal muscle exercises for no more than 20 repetitions with 3 minutes of treadmill running immediately following each exercise with verbal feedback. This exercise-run intervention was repeated 3 times at each training session. Recovery after each session was 48-72 hours. The final two sessions were identical to the initial session, with the final session occurring approximately two weeks following the post-training session. **Main Outcome Measures:** Independent variable was Time (Pre, Post, 2wks Post), and the dependent variables were peak HADD and peak HIR during stance phase, VAS maximum pain level during running and maximum hip external rotation peak torque. Separate Freidman's tests were utilized for each dependent variable, with Wilcoxon signed-rank test for post hoc analysis. **Results:** We observed a significant reduction in pain from Pre (4.2±1.1) to 2wks Post (1.6±1.8) (p=.042) time points. Hip external rotation strength increased from Pre (4.1±1%) to Post testing (4.8±.7%) (p=.03). There were no significant changes across time in average peak HADD (Pre 19.4±5.3°, Post 20.5.3±5.8°, 2wks Post 18.7±3.7°) (p=.513) and HIR (Pre 9.5±4.3°, Post 13.3±9.1°, 2wks Post 16.4±8.3°) (p=.846). **Conclusions**: Following a two week short-term intervention utilizing awareness exercises targeting gluteal musculature, and verbal feedback during running, there was a significant decrease in pain and increase in strength in female runners with PFP. A longer intervention, traditionally 6-8 weeks, may be necessary to see kinematic changes. **Acknowledgement:** This project was supported by a 2010 NATAREF Osternig Masters Grant.

Dosage Effects of Neuromuscular Training Interventions To Reduce Anterior Cruciate Ligament Injury In Female Athletes: Meta-And Sub-Group Analyses

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Context: Consistent increases in number of anterior cruciate ligament(ACL) injuries and their associated long-term physical impact have resulted in the development and use of neuromuscular training(NMT) as a prophylactic intervention. Recent meta-analysis reports demonstrate the effectiveness of NMT to reduce ACL injury in female athletic population. However, among reviewed studies disparity of ACL injury reduction was observed, which may stem from differences in NMT duration and frequency. Thus, a series of sub-group analyses was performed to delineate the potential effects of training volume relative to the prophylactic effectiveness of NMT on ACL injury. **Objective**: To systematically review and synthesize previously published studies to evaluate dosage effects of NMT on reduction of ACL injury in young female athletes. **Data Sources:** A computerized search was performed using PubMed, CINHAL, Medline, SPORT Discus, (1995-2012) in May, 2012. Key words were "anterior cruciate ligament", "ACL", "prospective", "neuromuscular", "training", "female", and "prevention". Abstracts and unpublished data were excluded. **Study Selection:** Criteria for inclusion required that 1)number of ACL injuries were reported, 2)NMT program was utilized, 3)females were included as participants, 4)studies used prospective, controlled trials, and 5)NMT duration and frequency were documented. **Data Extraction:** Study quality was assessed with the PEDro scale. Extracted data included the number of ACL injuries and the number of subjects in the NMT intervention and control groups. The extracted data were further classified by NMT duration (Short=Less than 20 minutes per session vs. Long=More than 20 minutes per session), frequency (Single=One NMT session per week vs. Multi=At least two NMT session per week) and volume (Low=Up to 15 minutes per week during in-season vs. Moderate=15-30 minutes per week during in-season, vs. High=More than 30 minutes per week during in-season). Odds ratios(OR) were used to compare a ratio of ACL injuries between intervention and control groups among the dichotomized and tertile analyses. The quality of evidence was assessed using the Strength of Recommendation Taxonomy (SORT) – Levels of Evidence. **Data Synthesis:** Fourteen studies met inclusion and yielded average PEDro score of 4.8/10(range: 2 to 7). Results are presented as OR [95%Confidence Intervals]. Fewer ACL injuries were documented in Long(OR 0.35: [0.23,0.53]) than Short(OR 0.61: [0.41,0.90]) duration. Also, fewer ACL injuries were recorded in Multi(OR 0.35: [0.23,0.53]) compared to Single(OR 0.62: [0.41,0.94]) frequency. The tertiary analysis indicated statistically fewer ACL injuries in High(OR 0.32: [0.19, 0.52]) compared to Moderate(OR 0.46: [0.21,1.03]) and Low(OR 0.66: [0.43,0.99]) volume. The SORT reached evidence level A. **Conclusions:** Results of the dichotomized analyses revealed dosage effects in NMT duration and frequency on ACL injury. The inverse dose-response relationship observed in the tertile analysis recommend higher NMT volume, precisely more than 30 minutes per week, to demonstrate greater prophylactic effect of NMT to reduce ACL injuries in female athletes.

Combined Landing, Core, And Jump Training Modifies Lower Extremity Energetics During Single-Leg Landing In College Handball Players: Implications For Anterior Cruciate Ligament Injury Prevention

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Context: Non-contact anterior cruciate ligament (ACL) injuries are known to be more common in female than in male athletes, such as handball players who frequently perform sudden deceleration–acceleration motions; these athletes are at high risk for such injuries. **Objectives:** To examine the effects of combined landing, core, and jump training on lower extremity energy absorption during single-leg landing and to determine the risk of non-contact ACL injury in female handball players. **Design:** Intervention **Settings:** Training facilities and laboratories. **Patients or Other Participants:** Twenty-three Japanese female division I college handball players(age, 20.0 ± 0.8years;height, 162.4 ± 4.9cm, and weight, 59.1 ± 5.7kg). **Intervention:** The subjects participated in a 5-month training program of core and jump-landing training for 1 month and high-intensity core, jump-landing, and jump training for 4 months. Before and after the training period, 3-dimensional biomechanical data were collected using electromagnetic motion tracking system and a force plate while subjects performed single-leg landings from a 30-cm box. **Main Outcome Measures:** Biomechanical data were collected from non-takeoff (NTOL) and takeoff legs (TOL) when shooting a handball. The negative work (J) of the sagittal plane hip(HW), knee(KW), and ankle joint(AW)during the descending phase of single-leg landings were calculated. A two-way (joint × training) repeated measures ANOVA examined differences before and after training. If a significant interaction was observed, a paired sample *t*-test was used to determine the difference in work for each joint. **Results:** The ANOVA revealed a significant increase in the negative work performed by each joint (pre-training vs post-training: NTOL=-60.2±54.0 vs.-68.2±33.5, $p<0.05$; TOL=-62.4±39.6 vs. -72.3±24.9, $p<0.01$) and interactions for both legs($p < 0.01$). The paired sample *t*-test revealed a significant increase in HW(NTOL=-3.4±16.5 vs. -52.4±28.1, $p<0.01$; TOL=-23.1±21.0 vs.-67.8±24.8, $p < 0.01$)and a reduction in KW(NTOL=-123.2±29.1 vs.-103.6±20.4, $p=0.01$; TOL= -101.8±23.1 vs.-86.0±20.2, $p<0.05$) for both legs. No significant changes in AW were observed (NTOL= -54.0±17.4 vs.-48.5±17.0; TOL= -66.7±20.6 vs.-62.0±19.3, both $p>0.05$) **Conclusions:** HW was lowest and KW greatest during single-leg landing before training. However, a significant increase in HW and decrease in KW were observed after training. Thus, combined training may decrease the possibility of excessive quadriceps muscle activations without hamstring muscle co-activations during decelerating moves such as single-leg landing, which have been suggested to reduce knee stability and increase ACL strain and injury risk.

Strength Changes Following Quadriceps Or Hip Focused Rehabilitation In Patients With PFP: An Outcome-Based RCT Study

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Context: Patellofemoral pain syndrome (PFPS) is the most common injury experienced by running- and jumping-based athletes. Traditionally, the gold standard for PFPS rehabilitation has been strengthening the knee musculature. More recently, the etiology of PFPS has been suggested to be related to reduced hip and core strength. However, no large-scale randomized controlled trials (RCT) have been conducted to determine the optimal rehabilitation for PFPS. **Objective:** To compare strength changes in knee extension (KEXT), hip abduction (HABD), hip external rotation (HER), and hip extension (HEX) before and after a 6-week treatment protocol focused on the knee (KNEE) or hip/core (HIP) musculature in physically active PFPS patients . Comparing strength changes in those who had a successful treatment outcome was a secondary objective. **Design:** Single-blind RCT multi-centered study. **Setting:** Four clinical research laboratories across North America. **Patients or Other Participants:** 202 PFPS patients, assessed by an AT and meeting inclusion criteria based on Boling et al. (2006), volunteered to participate, 135 patients had complete strength measure data (43 males, 92 females:

age= 20.0±7.1 years; mass= 67.6±13.5; height=170.4±9.4cm). **Interventions:** PFPS patients were randomly assigned to a treatment protocol: KNEE vs. HIP. Each subject visited an AT 3 times per week over a 6-week period for rehabilitation progression. **Main Outcome Measures:** Isometric peak strength was recorded using a force dynamometer for KEXT, HABD, HER, and HEX. Peak force was normalized to body weight (N/Kg) and used as the dependent variables. Treatment success was a priori defined as a decrease in VAS by 3cm and/or an increase in AKPS of 8 points (SUC vs UNSUC). Data were analyzed using an intent-to-treat basis. We performed a 2x2x2 ANOVA (rehab group x time x success; $P \leq 0.05$) on the dependent variables. **Results:** Multivariate analyses indicated no significant interactions among rehab group, time, and success (F=.96-1.7; *P*=.14-.726). There was a significant multivariate effect for TIME (F=6.28, *P*<.005). Regardless of rehab group or treatment success, HABD(F=12.38,p=.001), HER(F=12.66, *P*=.001), HEXT (F=.6.6, *P*=.011), and KEXT(F=8.3, *P*=.005) strength significantly increased following the 6-week intervention HABD(Pre:3.38±1.17, Post:3.63±1.19), HER(Pre:1.19±.43, Post:1.32±.42), HEXT (Pre:2.44 ±1.05, Post:2.76±1.22), KEXT (Pre:3.95±1.54, Post:4.40±1.48). There were no other significant main effects for rehab group or treatment success. **Conclusions:** Both the KNEE- and HIP-focused rehabilitation programs resulted in significant strength gains in all of the muscle groups. It is possible that the exercises performed, regardless of group, caused enough muscle activation to produce strength gains, even if the exercises were not thought to target one particular muscle. The clinical application of these findings are that both quadriceps and hip focused strengthening seem to be equally effective for producing strength gains, and should be prescribed based on individual patient impairments. Funded by the NATA REF: 808OUT003R and Alberta Innovates: Health Solutions.

Pain, Function, And Strength Outcomes For Males And Females With Patellofemoral Pain Who Participate In Either A Hip- Or Knee-Based Rehabilitation Program

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Context: Patellofemoral pain (PFP) is a common pathology experienced by individuals who participate in running and jumping-based sports. While quadriceps exercise is the gold standard intervention, evidence exists regarding the importance of hip/core (HIP) strength. Moreover, researchers have shown that, unlike males, females exhibit altered landing and running mechanics, possibly from reduced HIP strength, that contribute to PFP. Thus, females with PFP may respond more favorably to a HIP rehabilitation protocol than a knee-focused (KNEE) program. However, no study to date has investigated this hypothesis. Identification of these differences could help clinicians implement sex-specific interventions for patients with PFP. **Objective:** To compare improvements in pain, function, and strength between males and females with PFP who participated in a HIP or KNEE rehabilitation program. We hypothesized that no sex differences would exist in visual analog scale (VAS), Anterior Knee Pain Scale (AKPS), or hip and knee strength measures. **Design:** Single-blind randomized controlled trial multi-centered study. **Setting:** Four clinical research laboratories across North

America. **Patients or Other Participants**: 185 patients with PFP, who met inclusion criteria (Boling et al., 2006), participated (60 males: age=29.9±7.5 years, mass= 79.6.8±11.4 kg, height=178.6±6.6 cm; 125 females: age=29.1±7.4 years; mass=63.6±11.7 kg; height= 166.6 ±7.7 cm). Interventions: Patients were randomly assigned to a HIP or KNEE rehabilitation program. Each subject visited an AT up to 3 times per week over the 6-week period for rehabilitation progression. **Main Outcome Measures:** VAS and AKPS scores as well as hip abductor (HABD), hip external rotator (HER), hip extensor (HEXT), and knee extensor (KE) isometric strength measures were collected before and after subjects participated in a 6-week rehabilitation program. Data were analyzed using an intent-to-treat basis. Separate mixed-model 2X2X2 ANOVAs (sex x group x time; $P<0.05$) with repeated measures were used to determine differences in all dependent measures. **Results:** Regardless of sex or rehabilitation group, a significant reduction in VAS (mean difference=-2.6+0.2 cm; $F_{1,181}$= 201.1; P<.0001) and improvement in AKPS (mean difference=11.0+0.9 points; $F_{1,181}$=155.0; P<.0001) scores occurred. Similar improvements existed for HABD (mean difference=0.17+0.1 N/kg; $F_{1,181}$= 8.4; P=.004), HER (mean difference =0.10+0.0 N/kg; $F_{1,181}$=15.1; P<.0001), HEXT (mean difference =0.23+0.1 N/kg; $F_{1,181}$=15.9; P<.0001), and KE (mean difference =0.30+0.1 N/kg; $F_{1,181}$=12.4; P=.001) strength. Although not significant, females demonstrated modest improvements in HABD (5.4 vs. 4.5%; P=.617), HEXT (11.3 vs. 7.4%; P=.825), and KE (8.0 vs. 6.8%; P=.998) strength than males while males exhibited greater improvement (10.5 vs. 5.8%; P=.210) in HER strength. **Conclusions:** Regardless of sex, subjects with PFP benefitted from a HIP- or KNEE-based rehabilitation program. The fact that males and females had relatively similar improvements in HABD and KE strength supports the importance of exercises targeting these muscles for all patients with PFP. However, clinicians should consider prescribing exercises that specifically target the HEXT for females and HER for males.Funded by the NATA REF: 808OUT003R.

Whole Body Vibration Reduces Quadriceps Arthrogenic Muscle Inhibition Induced By Experimental Knee Joint Effusion

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Context: Quadriceps arthrogenic muscle inhibition (QAMI) is a common symptom following knee injury which impedes rehabilitation and may increase the risk of subsequent injury and osteoarthritis. Whole body vibration (WBV) facilitates quadriceps function and may minimize QAMI. However, the effects of WBV on QAMI are unknown. **Objective:** To evaluate the effects of WBV on QAMI following experimental knee effusion. **Design:** Randomized controlled trial. **Setting:** Research laboratory. **Patients or Other Participants:** Seventeen healthy volunteers were randomly assigned to WBV (n = 9; Mass = 71.5 ± 13.9kg; Height = 1.7 ± 0.1m Age = 21.0 ± 1.2 years) or Control (n = 8; Mass = 71.2 ± 19.5kg; Height = 1.7 ± 0.1m Age = 22.0 ± 3.5 years) groups. **Interventions:** QAMI was induced by ultrasound-guided injection of 60mL of saline into the knee joint space. Both groups performed the same intervention on a WBV device (6 one-minute repetitions of an isometric squat), but only the WBV group received the vibratory stimulus (30Hz, 2.6g). Quadriceps function was assessed at baseline, post-effusion, and post-intervention. **Main Outcome Measures:** Quadriceps function was evaluated via peak torque (PT), rate of torque development (RTD), and Central Activation Ratio (CAR, resulting from a superimposed electrical stimulus) during maximal voluntary isometric knee extension. PT and RTD were normalized to body

mass. These variables were evaluated via 2(Group) x 3(Test) mixed-model repeated-measures ANOVA, and significant interaction effects were evaluated *post hoc* via Bonferroni's procedure. **Results:** The interaction effect for PT was significant (p = 0.048). PT decreased similarly in the WBV (= -22.2 ± 16.6%; p = 0.003) and Control (= -15.0 ± 15.0%; p = 0.004) groups following effusion. However, WBV increased PT (= 28.6 ± 21.4%; p = 0.002), but the Control group did not change (= 0.0 ± 11.8%; p = 0.263). The interaction effect for CAR approached significance (p = 0.077; Power = 0.65). Exploratory *post hoc* analyses indicated that while effusion decreased CAR similarly in both groups (WBV = -10.2 ± 11.9%, p = 0.017; Control = -9.4 ± 5.6%, p = 0.001), WBV increased CAR (= 12.5 ± 13.0%; p = 0.010), but the Control group did not change (= 0.9 ± 13.0%; p = 0.417). Though effusion decreased RTD in both groups (-51.2% vs. -46.7%), this decrement and the associated improvements post-intervention (54.8% vs. 60.4%) were similar between groups (interaction effect p = 0.898). **Conclusions:** WBV appears to be an effective mechanism for minimizing QAMI. Quadriceps strengthening following knee pathology is often limited due to QAMI. As such, WBV may be used to facilitate quadriceps function and enhance quadriceps strengthening, thus enhancing the efficacy of rehabilitation and potentially mediating the risk of subsequent injury and osteoarthritis.

Acceleration Through The Body During Whole-Body Vibration Is Affected By Vibration Parameters

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Context: Whole-body vibration (WBV) platforms have been used widely under various parameters most of which indicate benefits to a variety of physiological measures. However, studies using WBV do not follow specific protocols for determining what parameters are used, and few have measured the transmission of vibration thought the body. Analyzing the effects of WBV throughout the body could be useful information in determining effective dosage parameters in training with this modality. **Objective**: To determine the vertical plane acceleration transmission through the body as measured at the foot, knee, hip, and cervical vertebra. Our hypothesis was that attenuation of the vibration would occur from the foot through to the cervical vertebrae. **Design**: Counterbalanced control trial. **Setting**: Engineering and biomechanics research laboratory. **Patients or Other Participants:** 30 healthy young females (age = 21.7 ± 3.1 years, height = 65.7 ± 3.1 inches, weight = 137.3 ± 19.8 pounds) volunteered. **Interventions:** Participants performed 4 one-legged squat at 40 degrees of knee flexion on an oscillating WBV platform (VibraFlex 600). Trials were separated by 5 minutes of rest and repeated within subjects. Participants were exposed to four 15-second bouts of vibration consisting of two displacements (2mm and 4mm) and two vibration frequencies (15Hz and 30Hz). Trials were presented in a counterbalanced order. Three-axis accelerometers (Sparkfun electronics) were placed at the medial malleolus, the medial epicondyle of the femur, the anterior superior iliac crest, and the spinous process of the seventh cervical vertebrae. **Main Outcome Measures**: Acceleration (g) in the vertical plane at the four locations was collected. A repeated measures ANOVA was used to compare the four body points across variables. **Results**: In the vertical plane, acceleration measured at the foot and knee were affected by the interaction of displacement and frequency. At the foot the variables had a significant effect ($F=62.17$, $p<0.001$), such that the 2mm15hz (0.8904±0.44) < 4mm15hz < 2mm30hz < 4mm30hz (3.11±0.44). At the knee the 2mm30hz ((1.39±0.44)< 2mm15hz < 4mm30hz < 4mm15hz (2.90±0.55) ($F=35.75$, $p<0.001$). However, there were no interactions of main effects across variables at the hip ($F=0.89$, $P=0.372$) or cervical vertebrae ($F=0.313$, $p=0.578$). Main effects were seen at the ankle with an effect of frequency (30Hz > 15Hz, ($F=315.42$, $p<0.001$)) and at the knee with an effect of displacement 4mm > 2mm ($F=56.02$, $P<0.001$)). **Conclusions**: The transmission of vibration does attenuate through the body as measured by acceleration at different anatomical points in this study. The level of attenuation is not even throughout the body as the acceleration at the hip and cervical areas are negligible. As well, the effects of displacement and frequency on acceleration at the ankle and knee should lead practitioners to consider both the frequency and displacement when establishing WBV protocols.

Acceleration Through The Ankle During Whole-Body Vibration Affected By Footwear Condition In Females

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Context: No guidelines exist for selecting between shoe wearing (SW) and being barefoot (BF) while using whole-body vibration (WBV) machines. Understanding the transmission patterns of vibration through the foot in SW or BF conditions may play a role for appropriate selection of footwear during the use of WBV. **Objective** To determine whether acceleration of WBV is significantly reduced through the ankle in the vertical, coronal and sagittal planes by being barefoot or wearing a shoe. **Design:** Counter-balanced controlled trial. **Setting:** Engineering and biomechanics research laboratory. **Patients or Other Participants:** 30 healthy young females (age = 21.7 ± 3.1 years, height = 65.7 ± 3.1 inches, weight = 137.3 ± 19.8 pounds) volunteered. **Interventions:** Participants performed a one legged squat at 40 degrees of knee flexion on an oscillating WBV platform (VibraFlex 600). The SW and BF trials were separated by 5 minutes of rest and repeated within subjects. Participants were exposed to four settings (2mm15hz, 2mm30hz, 4mm15hz, 4mm30hz) for 15 seconds each in a counterbalanced order. Acceleration at the medial malleolus was recorded using a 3-axis accelerometer (SparkFun Electronics). **Main Outcome Measures:** Acceleration (g) was recorded in the vertical, coronal and sagittal axes at the medial malleolus for SW and BF conditions. The means were compared using repeated measure ANOVA to determine differences between conditions. Results: Vibration at the ankle was lower in SW compared to BF in the vertical-axis at all settings [2mm15hz (SW= 0.742±0.225, BF 1.039±0.317, $F_{1, 56}$ = 17.445, P = 0.001), 2mm30hz (SW= 2.355 ±0.619, BF 3.160±0.564, $F_{1, 56}$ = 27.751, P < 0.001), 4mm15hz (SW= 1.788±0.371, BF 2.040±0.256, $F_{1, 56}$ = 9.409, P = 0.003), 4mm30hz (SW= 2.911±0.522, BF 3.299±0.227, $F_{1, 56}$ = 13.865, P < 0.001)].Vibration at the ankle was higher in SW then BF in the coronal-axis [2mm15hz (SW= 1.674±0.316, BF 1.329±0.339, $F_{1, 56}$ = 16.663, P < 0.001), 2mm30hz (SW= 3.079±0.501, BF 2.199±0.706, $F_{1, 56}$ = 30.988 , P < 0.001), 4mm15hz (SW= 2.299±0.335, BF 2.029±0.312, $F_{1, 56}$ = 10.425, P = 0.002)] but was not significant at 4mm30hz. Vibration at the ankle in the sagittal-axis was not significant between groups and inconsistently varied in response to SW or BF conditions. **Conclusions:** The SW condition influences the medial/lateral ankle displacement more than BF and should be considered when using WBV on individuals with ankle pathology. Further work is needed to determine the interest of using WBV during rehab exercises for ankle sprains. The BF condition increases vertical loading at the ankle compared to SW which is important when using WBV to increase bone density.

Pre- And Post-Activity Stretching Practices Of Collegiate Athletic Trainers

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Context: Current research suggests the benefits of pre-activity dynamic stretching include an increase in sport-specific flexibility, strength, power, agility, and sprint performance. On the other hand, recent evidence demonstrates that pre-activity static stretching may actually decrease athletic performance, and is alternately recommended as a component of a post-activity cool-down routine. **Objective:** To investigate the knowledge and practices of collegiate certified athletic trainers (ATs) to determine if stretching practices utilized are in line with the current research. **Design:** Cross-sectional study. **Setting:** A population-based questionnaire administered via email with a hyperlink to the survey was used to conduct the data collection. **Participants:** A total of 2839 ATs, who are members of the National Athletic Trainers' Association and indicated the collegiate setting as the primary place of employment were emailed and invited to participate. A total of 500 participants (17.6%; 252 male, 248 female) completed the survey. **Interventions:** The "Pre- and Post-Activity Practices in Athletic Training Questionnaire" was administered electronically as each subject was contacted via email, with a brief description of the survey purpose and the hyperlink to the web-based survey. The survey consisted of demographic characteristics and multiple choice items related to athletic trainers' knowledge and use of pre-activity warm-up, pre-activity stretching, post-activity cool-down, and post-activity stretching. In previous studies, the survey demonstrated construct validity, ˜ = .722. **Main Outcome Measures:** Descriptive statistics were computed for all items. Pearson chi-

square test was used to evaluate goodness of fit, and kappa was calculated to measure agreement between the subjects. **Results:** 32.2% of collegiate ATs recommended dynamic stretching pre-activity, whereas 42.2% recommended a combination of static and dynamic stretching. However, post-activity, 60.6% of collegiate ATs recommended static stretching, while only 27.9% recommended a combination of static and dynamic stretching. There was a moderate level of agreement that of the collegiate ATs who recommend dynamic stretching pre-activity, 21% of athletes are actually performing dynamic stretching (K=.582, $P \leq .001$). Post-activity, there was a substantial agreement that of the ATs who recommend static stretching, 61.0% of athletes are actually performing static stretching (K=.761, $P \leq .001$). **Conclusions:** Collegiate ATs are employing practices that are not in line with current research, which recommends dynamic stretching be incorporated pre-activity as a means to prepare the musculoskeletal system for sports activity. There is a low percentage of collegiate ATs who are recommending, as well as athletes who are performing, dynamic stretching pre-activity. In addition, there is a great deal of collegiate ATs who are recommending a combination of pre-activity static and dynamic stretching. However, collegiate athletic trainers are emphasizing static stretching post-activity, and athletes are performing it post-activity, which is in line with the current research.

Acute Static Stretching Does Not Affect Golgi Tendon Organ Reflex Inhibition

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Context: Golgi tendon organ (GTO) disinhibition is thought to contribute to exercise-associated muscle cramp (EAMC) genesis. Despite limited evidence of efficacy, acute static stretching is often prescribed to prevent EAMC based on the belief that stretching activates GTOs. Gastrocnemius GTO inhibition is highest when the gastrocnemius is in a lengthened position, but no research has examined the effect of acute stretching on GTO inhibition. **Objectives**: We asked: Does a single bout of acute static stretching increase gastrocnemius GTO inhibition? If so, how long does GTO inhibition stay elevated post-stretching? We hypothesized GTO inhibition would increase post-stretching but would return to pre-stretching levels within 5 minutes. **Design:** Repeated measures, cross-sectional. **Setting:** Laboratory. **Patients or Other Participants:** Six men (age=26±3 y; ht=179.5±4.1 cm; mass=81.8±13.4 kg) and six women (age=27±7 y; ht=163.4±4.9 cm; mass=64.4±9.6 kg). **Interventions:** Subjects' dominant limb medial gastrocnemius GTO inhibition was tested before, immediately after, and 5, 10, 15, and 30 minutes post-stretching. With subjects long sitting, the investigators applied three, 1-minute bouts (1 minute of rest separating each bout) of static stretching to the gastrocnemius by placing the ankle into maximum dorsiflexion. To measure inhibition at each selected time interval, subjects maintained medial gastrocnemius contraction intensity at 5% of their maximum voluntary contraction EMG activity. While contracting, the Achilles tendon was stimulated 50 times (rectangular pulses, 75 mA, 100 µs duration, 2-s interpulse interval). Pre, during, and post-stimulus EMG activity for the 50 trials at each measurement time were filtered, full-wave rectified, and averaged. An algorithm (implemented using MatLab software) identified inhibitory points and calculated the main outcome measures. **Main Outcome Measures:** Inhibition area ($mV*ms^{-1}$), inhibition maximum (mV), and inhibition duration (ms). Outcome measures were normalized using 100 ms of pre-stimulus EMG activity. Repeated measures ANOVAs with Geisser-Greenhouse corrections were used to analyze data (˜=0.05, NCSS v.2007). Data are reported as means ± SD. **Results:** Inhibition area was unaffected by stretching at any time ($F_{1,14}$=1.5, P=0.25; pre-stretch =0.07±0.09 $mV*ms^{-1}$, immediately post-stretching= 0.07±0.10 $mV*ms^{-1}$, 5 min post-stretching=0.06±0.08 $mV*ms^{-1}$, 10 min post-stretching =0.05±0.04 $mV*ms^{-1}$, 15 minutes post-stretching=0.05±0.04 $mV*ms^{-1}$, 30 minutes post-stretching =0.05±0.05 $mV*ms^{-1}$). Inhibition maximum was also unaffected by stretching over time ($F_{1,14}$=0.2, P=0.72; pre-stretch= 0.0008±0.0009 mV, immediately post-stretching = 0.0008 ±0.0008 mV, 5 min post-stretching= 0.0008 ±0.0007 mV, 10 min post-stretching=0.0008±0.0007 mV, 15 minutes post-stretching= 0.0008± 0.0007 mV, 30 minutes post-stretching=0.0008±0.0008 mV). Stretching also did not affect inhibition duration over time ($F_{1,14}$=1.5, P=0.24; pre-stretch=3.5±2.8 ms, immediately post-stretching=3.3±2.8 ms, 5 min post-stretching=3.3±2.5 ms, 10 min post-stretching=2.8±1.6 ms, 15 minutes post-stretching=2.7±1.7 ms, 30 minutes post-stretching=2.7±1.8 ms). **Conclusions:** A single bout of static stretching had no impact on GTO inhibition. Single bouts of static

stretching are unlikely to prevent EAMC assuming the theory that GTO disinhibition contributes to EAMC genesis. The effect of chronic stretching programs on GTO inhibition warrants future examination.

Rehabilitation Program To Increase Knee ROM And Muscle Girth Following A 1-Year Absence From ACL Post-Operative Rehabilitation

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Background: An 18 year old male collegiate soccer signee reports having difficulty playing soccer for extended periods of time to the athletic trainer. The athlete could perform activities of daily living; however, his left thigh and knee become tight and painful during prolonged soccer drills and scrimmages. The athlete is 14 months post-ACL reconstruction (cadaver graft) with medial and lateral meniscus repairs on his left knee. Rehabilitation was initiated day 1 post-surgery. Rehabilitation consisted of knee range of motion (ROM) and strengthening exercises, moist heat, cryotherapy, and muscle stimulation 3 times a week for 3 months until he was able to walk without discomfort. At that time the athlete discontinued all rehabilitation. The injury, surgery, and initial rehabilitation were performed before the athlete signed with his college team. **Differential Diagnosis:** Post-operative arthrofibrosis, infrapatellar contraction syndrome, patella entrapment syndrome, cyclops lesion, and myositis ossificans. **Treatment:** Goniometer measurements revealed 110° of flexion and 7° of extension in his injured knee vs. 125° flexion and -1° in his uninjured knee. Thigh and calf girth measurements on both limbs 5cm and 15cm superior and inferior to the patella revealed a deficit on his injured side (thigh - 45.5cm and 61cm vs. 48cm and 64cm; calf - 40.5cm and 38cm vs. 38.5 and 40cm). Upon consultation with an orthopedic surgeon an aggressive rehabilitation program was implemented to increase both the patients' knee ROM and girth before considering surgical intervention. Knee extension was deemed most important and a rehabilitation protocol of moist-heat (20 minutes) and thermal ultrasound (7 minutes, 1 Mhz at 1.5 intensity) while the athlete remained in an extended knee position began on the distal hamstring. This was followed by deep tissue massage on the hamstring and patella, stretching, and ice with external compression in an extended knee position for 20 minutes. Hamstring curls, balance/ proprioception exercises, hip extensions, TKE's, straight-leg raises, and calf raises were implemented 1 week later. After 6 weeks, the athletes' knee extension and flexion improved by 3° and 4° respectively resulting in squat-oriented exercises such as: wall sits, wall squats, lunges, and slide board being introduced. Heat, ultrasound, massage, and stretching on the athletes' quadriceps was introduced at this time. At week 10, quadriceps extensions, stool scoots, general running/cutting drills, and team soccer practice were added as the athletes' ROM and girth continued to improve. Twelve weeks into rehabilitation, ROM was reevaluated revealing 117° of flexion and 2° of extension in his injured knee. Girth measurements for the thigh (47.5cm and 63cm) and calf (40.5 and 38.5) also improved. The ROM and girth measurements on the uninjured leg remained constant. The athlete was instructed to continue exercises and play soccer during summer vacation. Upon reporting for fall camp the athletes' ROM and muscle girth measurements were identical as when he departed. The athlete was able to practice and compete during the fall at a higher level with decreased discomfort compared to the spring. **Uniqueness:** Completing a rehabilitation program is vital for a successful outcome following ACL reconstruction. By discontinuing rehabilitation after 3 months, this patient demonstrated the pitfalls of not completing a properly designed and supervised program. Our protocol demonstrates that improvements in knee ROM and muscle girth are possible after a 1-year absence and surgical intervention is not always necessary. **Conclusion:** Delayed ACL rehabilitation can create significant scar tissue buildup resulting in decreased knee ROM, strength, athletic performance, and quality of life. Completing a properly designed and supervised rehabilitation program prevents deficits in knee ROM and muscle girth. Athletic trainers should educate their patients on the importance of adhering to and completing their rehabilitation program to prevent complications.

Case Study Report: Pectoralis Tendon Repair In A Collegiate Football Player

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Background: The patient is a 20-year-old male Division-I Football Player. He was involved in a motorized vehicle accident one weekend during the summer. Two days later, he reported to the Athletic Training Room, complaining of pain in the right pectoralis major. He informed the Athletic Trainer about the accident, but he could not remember an exact mechanism of injury. He only remembered being expelled from the vehicle onto the ground. Immediately following the accident he did not feel any pain. However, later that day he started to experience extreme pain and was unable to use his right arm to perform any activities of daily living. Physical examination by the Athletic Trainer revealed a lack of muscle function and contraction in the right chest/shoulder as well as pain with shoulder abduction and external rotation. **Differential Diagnosis:** Possible diagnoses included pectoralis minor strain and labrum tear. **Treatment:** The patient was seen by a physician that day and a Magnetic Resonance Image (MRI) was ordered and conducted that afternoon. Physical findings included pectoralis major weakness and a palpable knot in the medial portion of the muscle. The MRI revealed a complete tear of the right pectoralis major tendon from its humeral attachment. Surgery to repair the muscle was scheduled for two days later. Cryotherapy alone was the treatment course for about the first week. The patient was also instructed to wear a sling with a pillow at all times. Nine days post-operative, the patient had a follow-up with the operating physician. His staples and the pillow were removed. He was cleared to begin passive range of motion (PROM) external rotation (ER) at 0 degrees to 90 degrees, PROM abduction to 60 degrees, as well as putty exercises to strengthen his hand and forearm musculature. Two weeks post-operative he was cleared to begin PROM abduction to 90 degrees, PROM forward flexion to 120 degrees, and light forearm weights to increase grip strength. Four weeks post-operative, he was cleared to begin some ER and internal rotation (IR) Thera-Band exercises, underwater treadmill jogging, and leg workouts in the weight room as long as they did not involve his arms. The goal of this phase was to achieve all full range of motion but the last 10 degrees of abduction external rotation at the 90-90 position. Five weeks post-operative, the patient was cleared to begin biceps and triceps strengthening via dumbbells (high repetitions and low weight) as long as the pectoralis major was not stressed. He was also cleared to begin lateral raises and running outside in a straight line. Eight weeks post-operative, he was cleared to begin all pectoralis major strengthening exercises with high repetitions and low weight. Progression was as tolerated. He also began catching balls at practice. Nine weeks post-operative, the patient was cleared to begin light plyometric exercise. He also began running some routes and catching more balls at practice. Ten weeks post-operative, he was cleared to begin more strenuous plyometric exercise. He also began limited non-contact practicing. Twelve weeks post-operative, he began full non-contact practicing. Thirteen weeks post-operative, the patient was cleared for full-contact practicing and to play in the football game that week. **Uniqueness:** This case is unique because most pectoralis major rehabilitations take about 6 months for non-athletes to return to full activities. It is rare for an athlete to return to a high-contact sport in just 13 weeks. **Conclusions:** This injury typically requires a long-term recovery. However, having a highly motivated athlete and athletic training staff factored heavily into an optimal outcome for this patient to return to play as quickly and safely as possible.

Use Of Exos Splints In A Middle School Population

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Background: A 14 year-old middle school volleyball athlete with no past medical history of hand injuries was participating in a "punch for punch" game with a football athlete on 8/30/12 when she punched his occiput, feeling a pop in her right hand. Evaluation by the athletic trainer revealed pain and swelling over the head of the fifth metacarpal, with limited active and passive range of motion (ROM). The patient was given ice and instructed to follow-up with a physician the next morning. **Differential Diagnosis:** Boxer's fracture, hand contusion. **Treatment:** Physician's exam of the right hand revealed pain and swelling at the dorsal aspect of the hand over the fifth metacarpal. ROM was limited at the fifth metacarpalphalengeal joint, but normal at the proximal phalangeal and distal phalangeal joints, with no rotational abnormalities. Upon reviewing the radiographs, attending fellow and physician agreed on the final diagnosis of a right boxer's and fifth metacarpal neck fracture. She was placed in an Exos ulnar gutter splint with instructions to remove the splint daily only to wash her hand. On 9/18/12, subsequent exam and follow-up radiographs revealed the fracture to be mildly healed. The patient was placed in the Exos for an additional two weeks, with instructions to wash her hand daily and work on gentle ROM when out of the splint. On 10/2/12, four weeks from fracture, follow-up radiographs still revealed mild interval healing of the fracture. Examination revealed pain and swelling over the fifth metacarpal, ecchymosis over the dorsum of the hand, but normal ROM at the wrist, PIP and DIP joints. The patient was fitted for a larger size Exos splint to decrease irritation, but locked in due to the patient's previous noncompliance. On 10/8/12, the patient returned to the clinic complaining of skin irritation, and was advised to remove the splint at night and apply an anti-fungal cream. A cast was applied after no decrease in skin irritation on 10/10/12, with instructions to follow up as necessary until her next scheduled appointment. No problems were reported after application of the cast, and following its removal, she successfully completed a home exercise program. **Uniqueness:** New to the healthcare field, Exos splints are the world's first modifiable, waterproof, antimicrobial bracing system. When heated, the foam brace is molded and customized to the patient. The optional locking feature safeguards against unwarranted removal with its lock and key feature. Exos splints ensure a sawless removal and no need for removal during radiographs, due to radiolucent properties. Prior to skin irritation, this patient's boxer's fracture was successfully treated with an Exos ulnar gutter splint, allowing her to shower, as well as perform gentle ROM exercises to decrease risk of hypomobility following fracture healing. It is unknown if this patient's skin irritation is correlated to use of the Exos splint. **Conclusion:** Exos splints can be used to stabilize a variety of upper extremity injuries. The splints allow for basic human necessities and rehabilitation, and guarantee against removal in noncompliant and adolescent patients. However, the locking feature is only successful if enforced. In this case study, the lack of parental enforcement led to insufficient healing and the eventual application of a cast. There is also currently no literature to support or confute Exos use. This gap in the literature can be closed through case series studies that examine the use of Exos technology. Given the advertised benefits, it is important that Exos splints are recognized as an option for upper extremity fractures, but situationally used.

Functional Postoperative Rehabilitation Of A Division 1 Swimmer

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Background: Athlete is a 21 year old male swimmer. He is a breaststroke specialist. After 33 days of practice the athlete began complaining of bilateral anterior medial knee pain. He was tender to palpate on the patella tendons of both knees. No joint line pain. No previous history of knee pain. Limited ROM due to pain in all knee motions. Manual Muscle Test 4/5 with pain in all knee motions. **Differential Diagnosis:** Meniscal and ligamentous pathology were originally suspected as was patella tendinitis. This was reinforced by the relief of pain when using a patella strap. Also considered subpatellar bursitis, that was ruled out as well due to area of pain. Treatment: MRI and Xray were both negative. Athlete was diagnosed by the team physician with bilateral knee synovitis. He was treated conservatively during the season without surgery. He was treated daily with the focus on increasing strength without pain and decreasing the swelling within the knee joint. He was immediately limited during team strength training, and breaststroke during practice. A patellar strap was used on the patella tendon because it decreased pain. A daily maintenance rehab plan was put in place. 3 days a week he completed a warm up on the stationary bike, table slides, prone quad sets, 4 way straight leg raises, step ups, terminal knee extensions, mini-squats, weighted knee extension and flexion, calf raises, and proprioception exercises. During off days the rehabilitation was focused on pain management through the use of cold and electric stimulation modalities. After the season was completed he had arthroscopic surgery on both knees. During the procedure, the meniscus appeared intact, scar tissue was removed from the joint, and the synovial lining of the joint was surgically excised. The first four days post surgery he used cold modalities, and completed ROM exercises. Five days post, strengthening exercises began. As soon as he was cleared to enter the water, he began rehab in the therapy pool. Freestyle was the only stroke used the first week in the pool. He then began progressing into breaststroke. He used a kick board to isolate the kick. Jet speed was adjusted to slow down his kick and focus on a pain free functional range of motion. Once achieved, the jet speed was increased and a resistance cord was added to help strengthen. Focus was then placed on the deep knee flexion associated with pushing off the wall. Athlete returned to competition the following season with personal best times in his first meet back. **Uniqueness:** A nonsurgical treatment was taken during the season in order to keep him competing. The unique aspect is the functional rehabilitation that was performed using an underwater treadmill and underwater jet resistance training. To isolate each phase of the stroke in a controlled tank was a unique opportunity to make sure that the swimmer was rehabilitating without affecting his stroke mechanics. The size of the pool used also provides the clinician a unique chance to change specific aspects of the rehabilitation to advance the treatment and make the rehabilitation as functional as possible. Video recordings were taking in order to give the athlete appropriate feedback on his progress. **Conclusions:** Although most sports have a generally accepted method for functional rehabilitation, swimming does not. The inclusion of an isolated tank with resistance jets into the rehab adds to the functional application of the exercises and hopefully a hastened return to play. This method was also used to rehabilitate a 21 yr old swimmer post shoulder arthroscopy and a 20 year old swimmer post repair of a compound femur fracture.

Upper Extremity Paresthesia In A Collegiate Swimmer

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Background: A 20 year-old male individual medley and backstroker presented with idiopathic persistent cervical spine pain and paresthesia in the upper extremities and jaw. Reported symptoms started four years ago bilaterally, but recently became more prevalent on the right side. He reported being able to perform sport activities on a self-limiting basis. Symptoms increased throughout the day and decreased with lying down. The patient's medical history was not significant for traumatic injuries to the spine or surrounding area. Visual observation revealed increased cervical lordosis with forward carriage of the head and chin protraction along with thoracic kyphosis and associated rounded shoulders. Physical examination elicited bilateral diffuse cervical spine tenderness, upper cervical extensor muscular spasms, and normal skin temperature. AROM testing revealed lower cervical and upper thoracic spine hypomobility and induced symptomatic increases with bilateral cervical extension, lateral flexion, and rotation. PROM testing revealed sternocleidoid, trapezius, levator scapulae, and pectoralis major and minor tightness. MMT elicited deep anterior cervical, serratus anterior, and scapular retractor weakness. Cervical compression, cervical distraction, Spurling's, Roos, and military brace tests were positive; however, valsalva maneuver and Adson's and Allen tests were negative. Neurologic testing revealed significant bilateral sensory and motor deficits over the entire right upper quarter. **Differential Diagnosis:** Rheumatoid arthritis, multiple sclerosis, tumor, cervical spondylolysis, degenerative osteoarthritis, spinal stenosis, cervical disk herniation, clinical cervical instability, facet joint dysfunction, degenerated facet joint, and cervical radiculopathy. **Treatment:** The patient was referred to the team orthopedist and removed from athletic participation. Following initial consultation he was referred to a neurologist who ordered blood tests and an MRI of the brain and cervical spine. Blood tests were normal. The MRI of the cervical spine revealed mild asymmetric right-sided uncovertebral hypertrophy at C2-C3 and C3-C4 with mild-to-moderate neuroforaminal stenosis. A mild mass effect on the left axillary sleeve at the C3-C4 segment was noted. A small subannular fissure and left central/subarticular disc protrusion encroaching on the left axillary sleeve and neural foramen at C5-C6 was observed. The neurologist diagnosed the patient with polyradiculopathy secondary to C2-C6 neuroforaminal spinal stenosis and was prescribed Carbamazepine ER for abnormal nerve sensations, Voltaren for inflammation, and rehabilitation to facilitate recovery and function. The rehabilitation program involved an integrated approach and was designed to control inflammation, provide symptomatic relief for radicular pain and muscular spasms, and to decrease cervical nerve root compressive forces. It consisted of physical agents, postural retraining, manual therapy, kinesiotaping to encourage correct posture, and therapeutic exercises to release tight structures and strengthen postural muscles. Status post four months his symptoms improved, but did not completely resolve. Participation was self-regulated and related to pain levels and neurologic deficits. Status-post six months his symptoms completely resolved. He was cleared for unrestricted activity. His return to swimming did not elicit any pain or neurologic deficits. **Uniqueness:** Most common clinical symptoms of polyradiculopathy are neck pain and unilateral arm pain accompanied by motor and sensory deficits. The prevalence of polyradiculopathy secondary to spinal stenosis increases with age and most commonly occurs at C6-C7 and in adults over 30-40. Furthermore, the patient is a post-pubescent athlete who developed early onset cervical spinal stenosis. Finally, only 2% of all cervical radiculopathies occur at C4-C5 or above. **Conclusions:**. Polyradiculopathy refers to compression or damage of more than one spinal nerve root that produces pain and neurologic deficits. This occurs when the spinal column narrows and places pressure on multiple nerve roots. The lower cervical nerve roots (C5-C8) are most commonly involved. Various etiologies can result in pressure on one or more cervical nerve roots. In this case, the pathology was caused by neuroforaminal spinal stenosis secondary to overactivity.

Chronic Upper Extremity Neurological Symptoms In A High School Football Athlete

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Background: Athlete is a 17 year-old male high school football linebacker. The athlete presented to Certified Athletic Trainer (ATC) during his junior football season after prolonged history of chronic bilateral stingers. Athlete noted he had been examined by orthopedic physician as well as treated by other allied healthcare professionals including ATCs and PTs. The ATC conducted orthopedic examination and a full bio-mechanical upper extremity examination. Biomechanical examination revealed athlete was experiencing bilateral scapular dyskinesis. Specifically bio-mechanical examination revealed forward head posture (FHP), increased kyphosis, and hypertonic upper trapezius and sterno-cleidomastoid musculature (SCM). He also presented with hypomobile first rib as well hypomobile lower cervical and upper thoracic vertebrae. Athlete continued to demonstrate full range of motion (ROM) which revealed decreased rotator cuff strength; bilateral sensation, reflexes, and shoulder ROM WNL. ATC presented current findings to Team Physician where MRI was ordered to rule out any cervical neck pathologies. MRI revealed uncovertebral joint spurring, and no other significant findings. **Differential Diagnosis:** Soft Tissue Contusion, Subluxation, Cervical Neck Pathology, AC Sprain, Transient Brachial Plexopathy (Stinger) **Treatment:** The athlete was treated conservatively with the ATC initiating a detailed rehabilitation plan addressing the scapular dyskinesis. Specific scapular stabilization exercises were focused on re-education and promoting proper scapula humeral rhythm utilizing PNF patterns for the scapula. Hypomobility of the first rib, upper thoracic and lower cervical vertebrae were addressed with graded joint mobilizations to restore normal arthrokinematic movement. Soft tissue mobilization and myofascial techniques were administered to the soft tissue impairments including the SCM, upper trapezius and pectoralis major/minor. Athlete was an active participant in his treatment process making ergogenic changes at home and school for completing schoolwork and sleeping postures. Athlete responded well to treatment as evidenced by decreased scapular dyskinesis and improved forward head posture and was able to return to participation. However, during the post-season, athlete was participating in physical education course and experienced a subsequent stinger resulting from non-traumatic mechanism of injury. Athlete reported to ATC and in consultation with Team Physician elected to refer athlete to a Neurologist for further evaluation. Neurologist conducted EMG. EMG revealed normal testing. Athlete, with prescribed rehabilitation program, has been able to complete senior year of football competition absolved from reoccurring stingers. Uniqueness: Stingers are a frequent pathology diagnosed and treated by ATCs with up to 65% of college football athletes having experienced a brachial plexus injury during their athletic careers. Most stingers resolve with conservative treatment of symptoms and general strengthening exercises with low incidence of re-occurrence. There is currently limited research on the rehabilitation for brachial plexopathy. This case highlights a thorough biomechanical evaluation to identify all impairments/dysfunctions. These discoveries allowed a detailed rehabilitation program to address and change athlete's biomechanics allowing better positioning and arthrokinematics, which when treated eliminated his chronic stingers. **Conclusions:** This case highlights the treatment of chronic bi-lateral transient brachial plexopathy. The athlete responded well to treatment and was able to return to full football competition and had had no episodes of stingers during his final season. Furthermore, this case highlights the importance of conducting a thorough biomechanical examination involving the entire kinetic chain and developing a rehabilitation plan that addresses tissue specific impairments. No current research explores the FHP/rounded shoulder posture in association with chronic stingers. This case demonstrates suggestion of a connection with the inflamed brachial plexus in the decreased space anteriorly with FHP. Increasing this space through addressing postural impairments assisted in relieving future brachial plexus injury. It also demonstrates that the use of diagnostic imaging is important, but ATCs need to continue to conduct a thorough clinical examination.

Upper Extremity Deep Vein Thrombosis In A College Baseball Player: A Case Study

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Background: A twenty-year old Caucasian, male, height 6'2, weight 185lbs, varsity athlete who is a right-handed pitcher on a division 1 baseball team reports with shoulder and arm pain. The athlete has been playing baseball since he was six year old and has no documented history of prior shoulder injuries or upper arm conditions, until two months prior to the manifestation of this condition when he strained his right pectoral. He has no known medical history of illness or acute injuries and patient's family history reflects no genetic, terminal or chronic illnesses. The patient's injury occurred during the preseason of his sophomore year. The patient's parents became concerned about their son after they noticed an obvious hypertrophy in his right arm only. When asked, the patient mentioned having shoulder fatigue, tightness and "weird" sensations at times. During inspection the patient presented with noticeable tautness of the skin and edema in the right bicep and triceps region and slight edema and tautness in the forearm. The patient had full range of motion in the shoulder and elbow, as well as full strength based on manual muscle tests and active range of motion tests. The patient tested negative for Thoracic outlet syndrome and was referred to a physician the next day. **Differential Diagnoses:** Thoracic Outlet Syndrome (TOS) and Chronic Exertional Upper Arm Compartment Syndrome (CECS) were considered as differential diagnoses. Both of these conditions mimic signs and symptoms exhibited by the patient. The patient tested negative for Thoracic Outlet Syndrome yet was never tested for Chronic Exertional Upper Arm Compartment Syndrome although he reported arm tightness, swelling, and some paresthesia of the fingers. A gross protrusion of a small artery in his right arm was noticed during a physician visit that warranted further immediate investigation. **Treatment:** The physician determined the patient had a possible Deep Vein Thrombosis (DVT). The patient was immediately sent to a local Emergency Room for a Doppler Ultrasound to rule out DVT. Upon receiving a Doppler Ultrasound at the local ER, the patient was determined to have a Deep Vein Thrombosis. The recommended treatment was a right para-clavicular thoracic outlet decompression including anterior and middle scalenectomy, brachial plexus neurolysis, and complete resection of the first rib; external venolysis of the subclavian vein; and an intraoperative upper extremity venography. Post-operatively, the patient was placed on anticoagulants and was allowed to start rehabilitation exercises. The patient had a full recovery and has completed his return to play program within seven months post-operatively. Uniqueness: UEDVT occurs in 2 out of every 100,000 people per year after strenuous activity like wrestling, rowing or pitching and is usually in their dominant arm. Incidence rates show that males are at a much greater risk for developing DVT than their female counterparts and their risk increases with their age. This patient had no predisposing factors for UEDVT other than gender and this condition manifested over time rather than acutely. **Conclusion:** Upper extremity deep vein thrombosis is a condition that usually affects the dominant arm of overhead athletes. This disorder should be suspected in athletes and patients performing repetitive overhead activities who develop acute-onset swelling. Treatment of this condition varies as does the underlying etiologies that cause this condition. Early detection and treatment of patients with UEDVT is important to successful treatment and progression to return to play. As athletic trainers, we are the first line of detection and referral of UEDVT in our upper extremity athletes.

Bilateral Neural Foraminal Stenosis Associated With Schmorl's Nodes In An Adolescent Football Athlete

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Background: We present the case of an otherwise healthy sixteen year-old high school football athlete who had been experiencing intermittent lower back pain for approximately two years. Although he could not identify a single traumatic episode during football or any other sport activity, he did suffer a fall while riding an all-terrain vehicle (ATV) just prior to symptomatic onset. He reported landing directly on the sacral area after falling off of the moving ATV, however he did not seek medical care at that time. Physical examination revealed normal lumber lordosis and minimal tightness of the lower lumbar paraspinals. Weight-bearing lumbar extension exacerbated pain while seated positions and lumbar flexion relieved symptoms. All tests were negative for radicular pain. Deep tendon reflexes, muscle strength and range of motion were all found to be within normal limits, while all sensory tests were negative. **Differential Diagnosis:** Zygapophyseal joint syndrome, spondylolysis, spondylolisthesis, lumbar degenerative disc disease, disc herniation, spina bifida occulta. **Treatment:** Upon referral radiographs were negative for vertebral malalignment, bone and joint abnormalities, and spina bifida occulta. Magnetic resonance imaging (MRI) revealed a Schmorl's node at the T12-L1 level. The MRI also revealed a bilateral neural foraminal stenosis from L3 to L5. A congenitally narrow central spinal canal with mild annular disk bulging was observed at the L3 through L5 levels and a decreased disc space height with mild annular disc bulging was observed at the L5 and S1 level. Due to the patient's age and severity of symptoms, he was treated conservatively with physical therapy. This consisted primarily of Williams flexion exercises and core strengthening. **Uniqueness:** Lumbar spinal stenosis is commonly diagnosed after middle age and secondary to years of degeneration, however those with a congenitally narrow central canal are more likely to develop symptoms at an earlier age. Our patient's symptoms began at age fourteen, which is considered extremely early for this condition. Foraminal stenosis is often associated with severe and radicular leg pain because the decreased space in the neural foramin causing impingement of the dorsal root ganglion. Our patient failed to report this, as his only symptom was intermittent localized lumbar pain. **Conclusions:** The diagnosis of foraminal stenosis is heavily dependent on both an in-depth patient history and body positioning during assessment. Symptomatic relief during rest and provocation during activities indicate the dynamic component of foraminal stenosis. Narrowing of this area can even occur with normal lateral flexion and extension motions in asymptomatic patients. Typically, patients presenting with lumbar stenosis will complain of localized back pain as well as radicular pain in the lower extremity upon standing. Symptoms are normally exacerbated by walking and other activity. While surgery is not uncommon, conservative treatment can provide successful outcomes. In the current case, the patient's symptoms have followed the desired course of regression following diagnosis and conservative treatment and he continues to participate in recreational sports without limitation. While cases of lumbar foraminal stenosis are rare in an athletic population, the symptoms of may present similar to lumbar pathologies seen more commonly in athletic populations. This emphasizes the need for a very thorough clinical examination.

Incidence Of Autoimmune Neuromuscular Hyper-excitability In A Division I Collegiate Athlete

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Background: A 19 year old female freshman Division I collegiate basketball player with a history of bi-lateral shoulder multi-directional instability presented to the athletic training room in March her freshman year complaining of spasms in her neck and trapezius. The patient had recently returned to activity following her third SLAP repair and thermal capsulorrhaphy. Increase in activity resulted in more spasm. The Athletic Trainer (ATC) referred the patient to the team physician, and she began taking Zanaflex. One month later the athlete complained of a tight right trapezius. The ATC performed a light stretch of the trapezius, and then applied electrical stimulation and ice. After five minutes the patient complained of discomfort and the ATC noted that the patients forearm and wrist were visibly contracted. The electrical stimulation was immediately discontinued. The patient's scapula was visibly depressed, her face appeared to have partial paralysis and she had slurred speech. The athlete was taken to the urgent care then transferred to the emergency room where blood work and a CT scan were performed. The results were normal and the athlete was diagnosed with Bell's palsy and an infection of the radial nerve. During the fall of her sophomore year, the patient was running sprints when she lost all motor control resulting in a collapse. Initial evaluation by the ATC noted nystagmus, abdominal rigidity and the athlete complained of not being able to move her legs or breathe. Upon relaxation, the symptoms resolved and she was referred to the team physician

and then a neurologist. Both of the doctors' findings were inconclusive and she was released. Later in the season the patient experienced similar issues in her left shoulder including dislocations and spasm. An episode of syncope and spasms occurred during a game and the athlete was taken to the emergency room. Altitude and elevated gallbladder enzymes were credited to the patient's episode. The patient was then referred to a second neurologist. **Differential Diagnosis:** Pinched cervical nerve, Viral infection of the radial nerve, Bell's Palsy, partial seizures, cervical dystonia, early onset torsion dystonia, Autoimmune neuromuscular hyper-excitability disease (Stiff persons syndrome), Neuromyotonia, Paroxysmal non Kinesigenic Dyskinesia, and Rheumatologic disease with CNS manifestations. **Treatment:** Upon referral to the second neurologist, diagnostic imaging was performed including an MRI, MRI Arthrogram, and a CT scan. Blood work screened her thyroid levels and ceruloplasmin antibodies. Screenings were performed to rule out: Wilson's Disease and Neuromyotonia. In addition, an EMG/NCV, EEG, and spinal tap were performed. The ATC also provided video footage to the neurologist to illustrate the severity of the spasms when they occurred. The video and results of the test confirmed that the patient suffered from autoimmune neuromuscular hyper-excitability disease. The patient was treated with Baclefen and allowed to return to full activity with follow-up care as needed. **Uniqueness:** This is considered a rare disease and its exact cause is unknown; however the cause is thought to be acquired, paraneoplastic or heredity. It can often be mistaken for ALS therefore instances within the athletic population are unheard of. This is a treatable disease with proper diagnosis and the symptoms may fluctuate in severity and frequency. **Conclusions:** ATCs need to continue to broaden their scope of knowledge related to various medical conditions. Symptoms can often be misleading however the ATC needs to continue to be an advocate for the patient and gather as much data as possible in order to ensure that a proper diagnosis can be made. Even though patients appear young and healthy, the possibility of unique diseases should never be ignored.

Cervical Spine Anomaly In A Collegiate Football Player

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Background: A 21 year old male Division I-AA wide receiver sustained a neck injury during a football game. The collision was helmet to helmet with a tucked chin, resulting in an axial load with subsequent hyperextension. He walked off the field and reported to the athletic training staff with complaints of neck pain in the left suboccipital neck region. Upon examination the athletic training staff noted no radiculopathy, no UE weakness, no cracking sounds/ sensations with movement, and no swelling or deformity. Pain increased with PROM: contralateral flexion, bilateral rotation, and extension. Any attempt of AROM could not be performed due to pain. The patient had previous history of neck pain on right side after being tackled in a game the previous season. **Differential Diagnoses:** Neck fracture, muscle strain, ligament sprain. **Treatment:** The orthopedic physician ordered x-rays to rule out any bony pathology. Radiographs were taken at the game using a portable device. The orthopedic physician deemed the x-rays abnormal and requested they be reviewed by a radiologist. The radiologist reported the x-rays to be negative. The patient was placed in a c-spine collar and underwent conservative modality treatment. During this time, the patient was monitored to determine if further testing was necessary. Two days after the initial injury, neck stiffness and pain persisted with manual axial load. Therefore, it was determined that further diagnostic testing was necessary and a CT scan was scheduled. The results of the CT scan revealed a congenital C1 anterior and posterior neural arch defect. An appointment with the team spine specialist was made for the following week to discuss

prognosis. The patient continued treatment with modalities and the use of a c-spine collar until his appointment with the spine specialist. During the appointment, the patient's CT scan was examined and x-rays in neck flexion and extension were taken to determine if there was any movement of the C1 vertebrae. No movement of the C1 vertebrae was noted. The spine specialist confirmed that the non-union of the anterior and posterior neural arch of C1 was a congenital anomaly. The initial recommendation by the spine specialist was to discontinue participation in football. However, further consideration was given regarding the lack of C1 movement and the physician cleared the athlete to return to football activities. However, the patient and his family chose to discontinue participation in football. **Uniqueness:** The literature reports that C1 anomalies occur in only 2% of patients, with combined anterior and posterior non-unions being the rarest. Most congenital C1 anomalies are asymptomatic, but can be symptomatic following trauma, such as the direct blow sustained in this case. It has been reported that the symptoms and appearance of a C1 anomaly can be similar to those exhibited with an acute fracture. Correctly diagnosing the C1 injury is important because the treatment of a C1 anomaly versus acute fracture is different. Furthermore, excess movement must be measured in these individuals via flexion and extension x-rays in order to determine the stability of the non-union arches. In this case, no movement was detected in the patient's flexion and extension x-rays. **Conclusions:** This patient sustained an axial load and hyperextension to his cervical spine resulting in the discovery of a C1 anomaly. His mechanism of injury suggested a cervical spine fracture but his ability to walk off the field and his lack of radiculopathy clouded the diagnosis. Athletic trainers need to be cautious when dealing with suspected c-spine injuries and continue to monitor associated symptoms. Spine anomalies are often difficult to identify on x-rays therefore a CT scan and/or MRI may be necessary.

Delayed Onset Compartment Syndrome Secondary To A Thigh Contusion In A Division 1 Men's Hockey Athlete: A Case Study

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Background: The patient was a twenty-year-old collegiate Division1 men's ice hockey athlete, 75 inches in height and weighing 205 pounds. The patient's significant medical history involved a Total Anomalous Pulmonary Venous Return at 11 months old, however this did not give suspicion to his injury. After he was hit with an opponent's knee and received a contusion to the left anterolateral thigh, this athlete had a severe increase in pain and edema, three days post-injury. Treatments applied to the athlete, during that time, included ice, compression wrap, stretching, deep oscillation therapy and pneumatic sequential compression. The athlete also took Non-Steroidal Anti-Inflammatory Drugs (NSAIDs), against medical advice. The athletic trainer measured his left thigh girth at 56 cm at 6 cm above the patella while the right was at 54 cm. The athlete's thigh was elevated 45° and his distal sensation and circulation was monitored with no noticeable change in either. **Differential Diagnosis:** While the initial concern was compartment syndrome, differential diagnoses considered were deep vein thrombosis, hematoma, acute ischemia, rhabdomyolysis, quadriceps contusion, femoral nerve injury, and myositis ossificans**. Treatment:** The physician, on site, noted the increase in swelling, severe pain, and inability to flex the left knee. The physician, concerned about compartment syndrome, took the patient for measurement of compartment pressures. His quadriceps

compartment pressure was measured at 23 mmHg and he was kept overnight for observation. The following day the patient had a sharp increase in symptoms and was taken to an urban level 1 trauma center. The pressure in the patient's quadriceps read between 55-60 mmHg with a diastolic blood pressure of 70 mmHg. The athlete was diagnosed with delayed onset compartment syndrome of his left thigh and an urgent fasciotomy was ordered to decrease the compartmental pressure. The fascia was released through an incision proximally and distally, significantly decreasing pressure throughout the thigh. Two days post-operation, due to an additional increase in pain and swelling, the fasciotomy was extended roughly 10 cm proximally and distally. The vastus lateralis was split along the femur and a large hematoma was completely removed. 97 days after the patient's initial injury, with rehabilitation from the sports medicine staff, he was able to return to Division 1 hockey. **Uniqueness:** The mechanism of injury and the development of symptoms are intriguing factors in this case. Although contusions are common in sports, delayed onset thigh compartment syndrome secondary to a contusion is rare. Compartment syndrome in the anterolateral compartment of the thigh is usually the result of blunt trauma in the form of femoral fractures and car accidents, rather than from a contusion. This patient also had a reduction of edema and pain after the initial injury, and then a sudden resurgence of both aspects three days post injury. **Conclusions:** Three days after receiving a contusion to the left anterolateral thigh, the patient had a spontaneous increase in pain and swelling. The next day, when the compartment pressure reached 55-60 mmHg, a thigh fasciotomy was performed. Two days post-operation, it was extended due to resurgence in symptoms. This case goes to show that delayed onset compartment syndrome can occur from a contusion to the thigh, therefore clinicians need to possess a high index of suspicion for this injury when blunt trauma is involved. Furthermore, the effects of pneumatic sequential compression and NSAIDs on the vascular system need to be taken into consideration when treating contusions. More studies are also needed on the effects of these treatments in relation to compartment syndrome. Further research is needed on the factors that influence clinical outcomes to determine proper treatment protocols.

Anterior Fibular Dislocation In A Collegiate Baseball Player: A Case Study

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Background: A 23 year old healthy male division one baseball athlete with no previous history of lower leg pathology sustained an injury to his left knee during a practice session on the turf in the indoor practice facility. The athlete was running to home base and stepped on the plate. Since this was in the indoor facility the plate was not secured to the ground and therefore slid causing the athlete's knee to hyperextend upon contact with the plate. The Athletic Trainer immediately evaluated the injury and found the athlete was complaining of anterolateral knee pain. Upon palpation it was noted that the fibular head was not in its correct anatomical position. The Athletic Trainer carefully raised the pant leg to further examine the athlete's knee. This revealed a large protrusion on the anterior aspect of the athlete's knee just lateral to the tibial tuberosity. It was suspected that the athlete's fibular head had dislocated anteriorly. The athlete was rushed to the University Orthopaedic Center for further evaluation by the team physician. **Differential Diagnosis:** Fibular head dislocation, Lateral collateral ligament sprain, Fractured Fibula, Posterior tibiofibular ligament sprain, Anterior tibiofibular ligament sprain. **Treatment:** The athlete was seen immediately by an Orthopedic Specialist. X-rays and a MRI revealed a dislocated fibular head. The physician tried but was unsuccessful at reducing the dislocation. The athlete was therefore scheduled to be reduced under anesthesia the next morning. The athlete was placed in an immobilizer, provided crutches and transported home. That evening the

athlete accidently slipped on his staircase and unknown to himself reduced his fibular head. X-rays were taken the following morning prior to his scheduled reduction which showed normal fibular alignment. The athlete was again placed in a straight leg immobilizer and provided crutches. The day after self-reduction, the athlete was point tender over the fibular head as well was the biceps femoris tendon. For the first week of rehabilitation the athlete completed quad sets, ankle pumps, and received Gameready treatment. The second week of rehabilitation consisted of a light resistance bike program and basic uniplanar lower extremity exercises. Further, the athlete discontinued the use of the crutches and began to fully bare weight. During week three the athlete was cleared to return to play as tolerated. The athlete began to hit balls off the tee, and field ground balls delivered straight towards him. During week four the athlete worked on ground balls directed away from him, started hitting live pitches and performing the following functional activities; running, sliding, and cutting. The athlete returned to play with no restrictions 35 days after the initial injury and finished the season with no complications. **Uniqueness:** Anterior fibular head dislocations are the most common type of fibular head dislocations however, the uniqueness of this case was in the mechanism of injury. Commonly, the fibular head is dislocated when falling on a flexed knee. In this case, the athlete described a hyperextension of his knee before the fibular head dislocated and relocated the fibular head by falling on a flexed knee. **Conclusion:** A 23 year old healthy male baseball athlete dislocated his fibula while running bases during practice. The athlete self-reduced by falling on a set of stairs. The athlete underwent rehabilitation for 35 day before returning to play. This case is important because it provides a base for rehabilitation for dislocated fibular heads. Further, it highlights the importance for athletic trainers to look beyond the mechanism of injury in their evaluation and differential diagnosis.

Compartment Syndrome Following Anterior Cruciate Ligament Reconstruction

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Background: An eighteen year old male high school senior presented clinically with a left knee Anterior Cruciate Ligament (ACL) tear, the mechanism of which was reportedly unknown by the patient. The patient's medical history included a previous left knee ACL tear which had been surgically repaired approximately 9 months previous to this current incident. The initial tear was during club soccer season in the summer. The patient's initial surgery and rehab were considered a success as he was able to return for the final half of his senior soccer season. Two weeks after the initial visit the patient underwent ACL revision surgery. Post operatively the patient was given an electric cooling device and instructions for usage and a prescription for narcotics to use PRN during the initial post-operative recovery process. The patient was instructed to begin therapy four days post-operatively. Two weeks post-surgery the patient presented in our clinic for his second post-operative visit. The patient presented with a mild knee effusion as well as calf swelling. He complained of intense pain in his knee and lower leg. He was immediately transferred to a local emergency department for further evaluation. **Differential diagnosis:** deep vein thrombosis (DVT), compartment syndrome. **Treatment:** An ultrasound was performed at a local emergency department for a suspected DVT. The ultrasound was negative for DVT. Intracompartmental pressure was taken which showed an increase in pressure consistent with compartment syndrome in a single compartment. A lateral release was performed. The patient was admitted to the hospital for

continued care and monitoring. He remained in the hospital for 3 days post lateral release with no recurrence of symptoms. Prior to hospital discharge the wound was closed and the patient was instructed to follow up with his surgeon in 3 weeks for both lateral release and ACL care. It was later revealed to orthopeadic staff that the patient had used the electric cooling device on a constant basis for 24 plus hours. We believe that this constant usages lead to a rebound phenomenon in the patient, leading directly to the compartment syndrome. **Uniqueness:** To our knowledge there are no other cases similar to this in the literature. There are no cases of rebound phenomenon in orthopeadic journals. There are cases that appear to be similar but the causes of compartment syndrome were attributed to either improper tourniquet usage during surgery or 1st degree frostbite caused by direct-to-skin contact of a cooling device. **Conclusion:** This case, while increidibly unique, illustrates the importance of following the manufacturer's recommendations when using an electronic cooling device. Electric cooling devices are becoming more and more common in athletic training rooms as well as use for in home for post-operative swelling and pain reduction. It also demonstrates the importance of communication following surgery and giving explicit instructions for post-operative treatment. After a lengthy physical therapy process in which the patient was relatively non-compliant, the patient regained full use of his foot and is now walking with a normal gait.

Traumatic Eye Injury In A High School Female Soccer Athlete

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Background: Athlete is an 18-year-old Hispanic female soccer goalie. Athlete had no previous history of concussion, eye injuries, or other significant medical history; however, athlete does wear corrective contact lenses while participating. The athlete, competing at an away competition, was defending the goal when she was struck in the left eye from an opponent's shot on goal from a distance of approximately 7 yards. Certified Athletic Trainer (ATC) was summoned onto the field for on-the-field assessment. Athlete presented with an epistaxis, but no cervical tenderness or pathology and was alert and oriented times 3. Further side-line examination revealed athlete complaining of transient oculus sinister vision that resolved by the completion of the examination. Concussion assessment including vitals, cranial nerve assessment, Standardized Assessment of Concussion (SAC) test, and Balance Error Scoring System (BESS) WNL. Host ATC educated athlete and guardian on potential signs and symptoms that would constitute the need for immediate referral and instructed the athlete to follow up with the ATC at her school the next day. During the follow-up exam completed the next day by ATC, the athlete presented with no signs or symptoms of a concussion, normal visual tracking, and PEARLA normal. Athlete complained of intermittent gray spots and blurry vision while looking down. ATC, in consultation with guardian referred athlete to an Optometrist which was further referred to an Ophthalmologist. **Differential Diagnosis:** Concussion, Cranial Nerve Pathology, Corneal Abrasion, Eye Orbit Contusion, Retinal Detachment Treatment: The Ophthalmologist completed comprehensive eye examination and diagnosed athlete with an atrophic hole within the left retina and commotio retinae. Athlete was withheld from all sport participation to limit increases in vitreous pressure which could leak to cause retinal detachment and was scheduled for Ophthalmologist follow-up appoint-ment in 5 weeks. At 5-week follow-up, athlete's signs and symptoms persisted, and as result underwent in-office Panretinal Laser Surgery (PRP). The PRP surgery produces scar formations to decrease the likelihood of the atrophic hole progressing to a retinal detachment. The PRP surgery ultimately corrected the athlete's symptoms. Athlete did not participate in spring sports or activity and had follow-up with ophthalmologist for spring pre-participation physical clearance. At that time, ophthal-mologist cleared athlete with no restrictions. **Uniqueness:** Acute traumatic atrophic retinal holes are extremely uncommon. Through an extensive literature review, most atrophic retinal holes are a result of chronic degeneration seen commonly in patients with diabetes and peripheral vascular disease. The atrophic holes occur in patients due to the vitreous humorous changing consistency causing a traction force which results in thinning of the retinal tissue. The athlete did experience commotio retinae, a common sign associated with countercoup eye injuries. Although commotio retinae does not directly produce inner eye swelling, it is a contributing factor for periretinal swelling which may have created the traction force required for the formation of the atrophic hole. **Conclusions:** This case highlights the diagnosis of an athlete with a traumatic atrophic retinal hole resulting from a blow to the ipsilateral side of the head.

The case is extremely unique since atrophic retinal holes are typically a result of age or diseases which contributes to thinning of the retina. This case highlights the need for the ATC to complete a thorough clinical examination. In this case, a head injury was able to be ruled out because of the comprehensive concussion evaluation being negative, but the ATC needed to continue to examine to explore causes for the visual disturbances that were presented. Case also highlights the prompt referral and management of a condition with unexplained clinical presentation. The athlete has made a full recovery and has not had any further problems or complaints.

Exertional Rhabdomyolysis In A High School Athlete

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Background: A 17-year-old, male, high school athlete reported to the athletic trainer (AT) two days after participating in a Physical Education (PE) class in which maximum weights and repetitions were completed. The athlete complained of severe bilateral arm pain, generalized body soreness, inability to sleep or fully extend his arms, and dark urine. The athlete was well-conditioned, had no previous history of injuries, surgeries, or other medical illnesses and denied use of power drinks, caffeine, stimulants, steroids, or supplements. The AT's examination indicated tenderness on the biceps brachii and forearms with limited elbow motion in both flexion (~90 degrees) and extension (~160-170 degrees). All other tests were negative; therefore the AT attempted massage, which did not diminish the pain or increase motion. **Differential Dx:** Delayed-onset muscle soreness, dehydration, exertional rhabdomyolysis, muscle strain. **Treatment:** Suspecting exertional rhabdomyolysis, the AT contacted the athlete's physician for consultation and exam. Physical findings noted: limited elbow extension (160-165 degrees at right elbow; 170 degrees at left elbow) and flexion (<90 degrees at right elbow; 80 degrees at left elbow); severe point tenderness on the anterior and lower portion of the biceps and the volar surface of the forearms bilaterally; normal grip strength; normal pulses at the wrist; intact sensation, normal strength; and no swelling or discoloration. Blood tests revealed creatine kinase (CK) levels >4500 u/L (normal range 33-145 u/L), confirming exertional rhabdomyolysis. The athlete was admitted to the hospital for intravenous fluids (IV) for hydration and IV fluid with bicarbonate for urine alkalization. After 3 days, the athlete was discharged with an acid-free fluid treatment plan and disqualified from all activities for the next 48 hours. Seven days post-injury, the athlete was allowed to participate in restricted basketball practice, but was disqualified from the PE class. After 14 days, the athlete was allowed to return to full practice with daily progressive 30 minute time allotments, but was still restricted from weight training. Three weeks post-injury, the athlete returned to full participation and was released for unrestricted weight training. No physical complications resulted from the exertional rhabdomyolysis. **Uniqueness:** Cases of exertional rhabdomyolysis in college athletes have been frequently reported over the last decade and continue to make the headlines as larger numbers of team members fall victim to this preventable condition. Cases of exertional rhabdomyolysis in high school athletes have just begun to be reported and have resulted from punishment drills or extreme training sessions. This case is unique given that the athlete was participating in a PE class that incorporated regular weight training sessions prior to this incident. In addition, the athlete's two younger brothers were in the same class and participated in the maximum weights and repetitions activity, but did not experience exertional rhabdomyolysis. **Conclusions:** Exertional rhabdomyolysis is the breakdown of muscle caused by excessive strenuous exercise. Exertional rhabdomyolysis can occur in individuals of any age, any fitness level, and while participating in any maximal exercise activity. The condition can mimic the muscle pain and limited range of motion associated with delayed-onset muscle soreness, making it easy to overlook. Exertional

rhabdomyolysis can be fatal if the symptoms are not reported by the athlete or if missed by the AT. The key signs and symptoms for early recognition and referral are dark colored urine and severe muscle pain a day or two after exercise. Elevated CK levels assist in the diagnosis. With this condition on the rise, the AT must continue to educate athletes, coaches, and physical educators about exertional rhabdomyolysis, exercise protocols and other factors that tend to contribute to the condition, the associated signs and symptoms, proper immediate care, and the potential complications.

Facial Pain In A Collegiate Football Player

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Background: An 18 year-old male football player with no previous related history presented to the athletic trainer with acute, severe, sharp mandibular pain accompanied by loss of function, malocclusion, and mild headache secondary to a direct blow. The patient was running while holding a 45lb rubberized weight during a spring season workout when he tripped and fell forward, dropping the weight which bounced off the floor and made direct mandibular contact. Pain quotient was described as a 9/10 with most of the discomfort being felt inside the mouth. Visual inspection revealed immediate severe swelling, moderate bleeding from a lip laceration, and gross deformity to the TMJ and mandible which appeared to be shifted to the right. Physical inspection elicited moderate point tenderness and deformity over the left TMJ and along the mandibular body without crepitus. The patient was unable to perform TMJ elevation, depression, or lateral deviation due to pain. No cervical pain or ROM limitations were reported. **Differential Diagnosis:** TMJ dislocation, closed head injury, tooth fracture, trismus, and mandibular fracture. **Treatment:** Direct pressure was applied to the laceration to control bleeding, a rigid cervical collar was applied for immobilization, and his airway was stabilized by the athletic training staff. EMS was summoned for transport to the emergency department. After initial consultation with the emergency medicine physician, he was referred to a maxillofacial surgeon. Maxillofacial radiographs revealed five fracture sites and the patient was subsequently definitively diagnosed with multiple unstable mandibular fractures on the body and condyles causing the TMJ to appear dislocated. Status-post three days, the patient underwent maxillomandibular fixation with wire osteosynthesis and braces to keep his teeth from shifting. He was placed on a strict liquid diet for two weeks, then permitted to progress to soft foods, and finally advanced to solid foods as tolerated. Two months post-maxillomandibular fixation, the patient was cleared for non-contact activity and resumed conditioning. Three months status-post, the patient made a full recovery and was expected to be medically cleared for unrestricted participation; however, he was ruled ineligible and is no longer participating in intercollegiate athletics. **Uniqueness:** Common etiologies of mandibular fractures include motor vehicle accidents and assaults, rather than sports, which account for less than 4% of reported cases. Mandibular fractures occur with an average of 1.5 to 1.8 fracture sites depending upon the mechanism; however, the incidence of four or more fracture sites is reported in less than .01% of cases. In addition to the number of fracture sites, the mechanism and location of the fracture sites make this case unique. The speed and angle of force with which the 45lb plate made contact with the mandible caused unique and multiple combination fractures along both the body and the condyles. Common fracture combinations include the angle and the body or condyle and the condyles and the symphysis. A final unique aspect of this case is that none of the fractures sustained were located under the third molar, which is the most common site. **Conclusion:** Mandible fractures occur as a result of the prominent position, distinctive shape, and lack of support of the bone. Patients suffering from mandibular fractures require airway stabilization and examination to rule out pathologies to the spine, brain, face, and teeth prior to maxillomandibular fixation and are

normally permitted to return to activity six to eight weeks post injury. Patients placed on liquid diets should be closely supervised and offered commercial meal replacements to ensure proper nutritional balance and sufficient caloric intake. In this case, the maxillomandibular fixation hindered the patient's nutritional status and oxygen consumption required by athletic participation which slightly delayed his anticipated return.

Second Toe Swan Neck Deformity In NCAA Mens Basketball Player

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Background: The subject was a 20 year old male NCAA Division I basketball player. The subject had an unremarkable history of a lower extremity phalangeal pathology. The 6'10" power forward reported to the Certified Athletic Trainer (ATC) complaining of severe pain over the ventral aspect of his right second toe during a basketball game. Initial evaluation revealed that during the push off phase of an attempt to "dunk" the basketball, the subject stepped on the posterior portion of a teammate's heel, hyperextending his right toes as he forced himself vertically. The subject felt an initial "pop" accompanied with sharp, severe pain in the involved toe. Initial observation revealed an obvious proximal interphalangeal (PIP) hyperextension deformity in the right second toe accompanied with slight distal interphalangeal (DIP) joint flexion. The subject was incapable of active flexion at the PIP joint (0 degrees). The subject was tender to palpation over the plantar aspect of the second toe. The ATC attempted to reduce an assumed PIP joint dislocation, which resulted in the reposition of the toe in the original deformed "swan neck" position. The subject was splinted and referred to an orthopedic surgeon. The orthopedic surgeon evaluated the subject, placed in a walking book and referred the subject to foot specialist for further inspection and imaging. **Differential Diagnosis:** Right second toe PIP dislocation; Right second toe phalangeal fracture; Right second toe flexor digitorum longus tendon rupture. **Treatment:** The x-rays displayed a swan neck deformity of the second toe. No notated signs of a PIP dislocation and a phalangeal fracture. The subject was diagnosed with a ruptured flexor digitorum tendon of the second toe. A phalangeal pinning procedure was proposed and executed by the foot specialist. Under fleuroscopic guidance, a 0.045 K wire pin was surgically implanted across the DIP and PIP joints of the second toe extending down into the base of the proximal second phalanx in attempt to promote bone healing at the plantar plate. The pin was secured and the right toe and ankle were immobilized using a custom toe splint and walking boot. The subject was non weight bearing for three weeks. The subject began lower extremity range of motion exercises and strengthening as part of a rehabilitation program three days post-surgery. In order to control and reduce the amount of muscular atrophy due to immobilization, the subject was placed on a maintenance based rehabilitation program focusing on right ankle, knee, and hip strengthening. The pin was removed three weeks following surgery. The subject's shoe was fitted with a custom orthotic featuring a rigid toe box to limit range of motion of the phalanges. The custom orthotic was worn throughout the remainder of the rehabilitation program and during return to play. **Uniqueness:** Traditionally, a flexor tendon rupture, known as a swan neck deformity is seen in the upper extremity phalanges rather than in the lower extremity phalanges. A swan neck deformity of the lower extremity phalanges is a rarity. To date, there are no case reports of a swan neck deformity to phalanges of the lower extremity. This extremely unusual toe hyperextension injury may be attributed to the uncommon forceful mechanism of injury. **Conclusion:** This case has demonstrated that a flexor digitorum tendon rupture can occur to the lower extremity phalanges, which may be overlooked in athletics because ATC's

and physicians are not familiar with this injury occurring to the lower extremity phalanges. It should not be assume that a swan neck deformity can only occur to the upper extremity phalanges. The injury can be successfully treated and allow the subject to return to play.

Ruptured Soleus Tendon In Middle-aged Runner

Ridgeway J, Jagger J: University of Kentucky Orthopaedic Surgery and Sports Medicine, Lexington, KY

Background: The athlete is a 48 year old female who runs on a frequent schedule for half marathons. She stated that she felt a pop in her posterior lateral right calf with an immediate onset of pain while running 2 weeks prior. The athlete stated that the muscle balled up with additional swelling, but no bruising. She said her current pain level is a 2 out of 10, which is gradually improving daily, and only takes naproxen as needed. She has had no previous injury or surgery to that area. **Differential Diagnosis**: Grastroc-soleus myotendinous strain, gastroc-soleus myotendinous rupture, mid-shaft fibula stress fracture, peroneal strain, peroneal rupture **Treatment**: The athlete was examined to have full strength and range of motion at the ankle and knee. She was tender along the lateral border of the gastroc-soleus musculotendinous junction. Upon palpation, the right calf has a fuller mass effect in comparison to the left. X-rays of the tibia and fibula revealed no fractures or joint dislocations with the soft tissue being within normal limits. The athlete was diagnosed with a possible tear of the gastroc-soleus musculotendionous junction. A MRI was ordered to confirm the diagnosis at her follow up appointment. In the interim, she was allowed to continue activities as tolerated due to the age of the injury. At her one week follow up, the results of the MRI confirmed a full thickness tear of her soleus at the myotendinous junction of the fibular sided tendon with surrounding edema and a mild strain of the medial head of the gastrocnemius. Upon examination, a lump can still be palpable at the injury site. Her edema and pain have both been reduced while retaining full strength and range of motion of the ankle and knee. She was instructed to start physical therapy for her nonoperative treatment, but did not return to clinic after this visit. She was contacted and verified that all her pain and edema had resolved, and was back to running again. **Uniqueness**: With only an incident rate of 0.7% of all gasctroc-soleus myotendinous junction injuries, an isolated soleus tendon rupture is a rare occurrence that could be easily misdiagnosed and ultimately mistreated. **Conclusion**: As seen with this runner, an out of the ordinary pop can lead to an uncommon injury, such as her soleus tendon rupture. With the help of advanced imagining, this injury can be correctly diagnosed, so that the correct corresponding treatment can be enacted. In her case, nonoperative physical therapy was the optimum course of action. Ultimately, with any athletic injury, anatomical and functional assessments with a thorough history allow an athletic trainer to confidently evaluate and treat an injury, even if the injury is uncommon and mimics other more common injuries.

Non-Contact Fibular Head Fracture In A Division III Collegiate Men's Basketball Player

Harris AM: Endicott College Beverly, MA

Background: A twenty year old NCAA division III men's basketball player reports with a non-contact fibular head fracture and associated LCL injury while attempting a break-away layup in a game; jumping from two feet with a deceleration, varus, and slight twisting motion to the knee. The athlete fell to the floor in immediate pain. Athlete was assisted off the court via 1 person carry and was evaluated. The athlete presented with immediate swelling and extreme tenderness to palpation over lateral aspect of knee extending to the fibular head. Patient was braced and sent to team orthopedic MD. The athlete denied history of knee injuries. Athlete also denied inversion mechanism at the ankle consistent with Maisonneuve type injury. **Differential Diagnosis**: Possible diagnosis based on location of pain included fibular head fracture, fibular head subluxation, LCL tear, lateral meniscus tear. Possible diagnosis based on mechanism of injury included ACL tear, PCL tear, acute meniscal tear, LCL tear. Assessment given prior to imaging was LCL tear with fibular head subluxation. **Treatment**: Orthopedic assessment along with radiographic imaging showed non-displaced fibular head fracture of the left leg. Patient was placed in CAM walking boot while performing low impact cross training for six weeks as well as treatment with non-thermal ultrasound and ice per MD protocol. Imaging received six weeks post injury revealed full healing of bony structure. Patient was then able to return to activity, progressing to full participation with no additional complications. **Uniqueness**: Fibular head fractures represent a small part of reported injuries sustained to the leg, with an even smaller percent of those being fractures. Most documentation and research has revolved around stress fractures to the fibula rather than occult fractures. The more common of fibular fractures reported are those of an avulsive type injury due to an outside varus force acting at the knee with or without a fibular head subluxation. There is no available literature on a fibular head fracture associated with a non-contact type mechanism that has only mild complications with the LCL. **Conclusions**: While a non-contact fibular head fracture is not common, it is possible that this can occur. Practitioners can use this case as a guideline if ever coming across a situation as unique in their clinical practice.

Rupture Of The Peroneal Retinaculum In A Collegiate Hurdler

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Background: A 20 year old male track and field athlete, who competes in 60m sprint, and 60m hurdle events, with no history of ankle injury reported to the athletic training room after landing inverted of his left ankle when jumping a hurdle during practice. He had minor swelling around the posterior aspect of his lateral malleolus. He was able to walk into the athletic training room with a significant antalgic gait. He complained of a sharp popping sensation when landing after clearing the hurdle. Upon observation he had minimal swelling but significant pain over his distal lateral fibula. He had significant subluxation of his peroneal tendons with dorsiflexion and plantarflexion, and described a popping sensation with these movements. Strength, and range of motion were fair for all directions both being limited by pain, **Differential Diagnosis:** Lateral ankle sprain, peroneal muscle strain, and subluxation of peroneal tendons. **Treatment:** The team Orthopedist was on campus and evaluated him within thirty minutes and diagnosed him with a ruptured peroneal retinaculum. The athlete insisted on trying to compete in the conference championship meet in two weeks. The Physician was willing to allow him to try and compete, knowing he could do no further damage. He was placed in a high tide walking boot on crutches non weight bearing for 10 days at all times and prescribed a Medrol dose pack to control inflammation. Treatments consisted of cryotherapy, compression, and interferential current electrical stimulation, to control swelling and pain. No strengthening or range of motion exercises were implemented. For the functional test and meet the athletic

training staff and Physician developed a way to stabilize the peroneal tendons in the retromalleolar groove. The athlete was taped using theraband tubing placed along the lateral fibula, to act as a bumper to prevent subluxation. Next we tape the distal third of the tibiofibular joint using a circular pattern with leukotape, which was applied with as much force as the athlete could tolerate. Lastly the ankle was taped in a standard way to provide support. He performed and passed a functional test two days before the meet consisting of hurdle-take offs and starting block take offs. He reported some pain but no subluxation or popping and was determined to try to run in the meet. The athlete ran in the preliminaries, and had a recurrent subluxation, but qualified for finals. During the final race he felt a sharp pop again, but was able to finish the race and placed 7th in the conference. Two weeks after the meet he under went a Peroneal retinaculoplasty surgery to repair the ruptured retinaculum. After 5 weeks in a posterior splint, athlete began rehabilitation, focusing on range of motion and strength. He started jogging at eight weeks, and hurdling at thirteen weeks and was cleared for full participation at 20 weeks post-op. **Uniqueness:** This is a unique case because there is limited literature to describe a conservative treatment technique that allows an athlete to participate for a short period of time prior to surgery. Using the three pillars of evaluation, anatomy, physiology, and biomechanics, along with patient values and our clinical expertise, we were able to make up for the lack of literature and we were able to develop an intervention that allowed our athlete to accomplish his goal of competing in the meet. **Conclusions:** This case demonstrated that this innovative taping technique could allow an athlete to achieve their goal of competing without adversely affecting the long-term outcome.

Navicular Avulsion Fracture In A Division I Field Hockey Player: A Case Report

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Background: A 20-year old female Division-I field hockey player, who was undergoing treatment for tibialis anterior tendonopathy, suffered an acute foot injury while performing a cutting maneuver during practice. The patient finished the drill and walked off with severely antalgic gait. The patient reported feeling a "pop" in her foot and immediate, severe pain over the entire foot and ankle region. Initial physical examination (PE) revealed no gross deformity, no edema, no ecchymosis, normal neurovascular screen, and generalized tenderness to palpation (TTP) over the foot and ankle region with moderate-to-severe TTP over the first tarsometatarsal joint. ROM tests revealed painful passive dorsiflexion and plantar flexion ROM. AROM was painful and limited in all directions, especially dorsiflexion. RROM was not assessed due to pain. The patient was iced for the remainder of practice. Following ice removal the patient was unable to WB without severe pain. Repeat PE revealed mild edema over the anteromedial foot region, continued TTP over the first tarsometatarsal joint, moderate TTP over the navicular tuberosity, first metatarsal, medial talar dome, and tibialis anterior tendon. ROM tests and neurovascular screen remained unchanged. Long bone compression test of first and second ray were negative, transverse arch squeeze test was negative, intermetatarsal distraction caused pain and torsion test was positive for pain, specifically combined pronation and eversion. **Differential Diagnosis:** Midfoot sprain, navicular fracture, metatarsal fracture, tibialis anterior strain, intrinsic foot muscle strain. **Treatment:** After 20minutes of cryotherapy, a compression wrap was applied to the foot and ankle and the patient was placed NWB on crutches and instructed to ice and elevate. One day post-injury the patient reported decreased pain but the PE remained unchanged. Rehabilitation was initiated with mild AROM and intrinsic foot strengthening exercises. Two days post-injury the patient was evaluated by the team physician who ordered x-rays which revealed a small navicular avulsion fracture. The patient was placed in a long leg cast and instructed to be NWB. Following one week of pain free NWB the patient was given a cast-shoe to begin walking in the cast. After two weeks additional x-rays were obtained and a bone growth stimulator was provided to wear while sleeping. The six weeks post-injury x-ray examination revealed full fracture healing and the cast was removed. The patient was given a short walking boot for 4-7 days while regaining strength. The patient progressed through a rehabilitation program to restore mobility, strength, neuromuscular control and power. Two weeks into the rehabilitation program, the patient experienced abnormal pain along the first ray. An x-ray revealed intact bone and a walking boot was prescribed until the pain subsided. After two days the patient was progressed out of the boot and re-initiated rehabilitation. The patient progressed to the functional phase of rehabilitation with no major complications, but has continued to report intermittent pain of varying severity. No specific cause of the pain can be identified. The patient is set to follow-up with an orthopedic foot specialist to explore the cause of her continued pain. **Uniqueness:** Navicular avulsion fractures are relatively rare injuries. This case involves a small avulsion of the dorsal portion from the dorsal talonavicular ligament that was treated conservatively. **Con-**

clusions: Mid-foot injuries can lead to long-term activity limitations and participation restrictions if not diagnosed and treated properly. Conservative treatment is usually sufficient for full recovery but operative treatment may be necessary for optimal outcomes in certain cases. In this case, conservative management and a graduated rehabilitation program produced satisfactory results and the patient is currently progressing to full participation.

Non-Contact Patellar Fracture In A Collegiate Football Player Following ACL Reconstruction

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Background: A 22-year-old collegiate offensive lineman sustained a non-contact knee injury during a preseason football practice. The patient reported that he stepped backwards, experienced a pop, and that it felt like someone kicked him in the knee. Upon initial evaluation by the athletic training staff diffuse swelling was present along with loss of active knee extension. The patient reported an 8/10 pain. Palpation findings indicated point tenderness over the anterior aspect of the knee and two separate bony prominences at the level of the patella. No knee special tests were performed due to the diffuse swelling, extreme tenderness, and deformity over the anterior knee. The patient was braced in full extension and immediately referred to the team physician for further evaluation. The patient's medical history was significant for an ACL injury approximately 9 months previously in which he was able to complete the season. Once the football season was complete he underwent ACL reconstruction utilizing a quadriceps tendon autograft. Following a structured rehabilitation program and functional return to football related activities the athlete was cleared to return to full activity approximately 7 months post-ACL reconstruction. **Differential Diagnosis:** Patellar tendon rupture, quadriceps tendon rupture, patellar fracture, tibial tubercle avulsion. Treatment: Following physician evaluation, x-rays were ordered. Results of the x-rays showed evidence of a transverse fracture along the equator of the patellar. The fracture was at the level of the bony defect resultant from the ACL reconstruction. One day following initial injury, the patient underwent an open reduction internal fixation procedure to repair the fracture. Four pins were inserted parallel to one another from the fracture distally and reinforcement wires were placed around the pins in a crisscross fashion. The initial post-operative treatment consisted of wound management and the patient was braced in full extension and allowed to weight-bear as tolerated with crutches. One week post-operative, a therapeutic exercise program was initiated to decrease pain, edema, and restore ROM. Active quadriceps contractions were not permitted during post-operative weeks 2-4, however assisted hip strengthening and ROM exercises were performed. Two weeks post-operative the staples were removed and exercises to decrease pain, edema, and restore ROM were continued. Following two weeks of immobilization in full knee extension, with crutch use, the patient was progressed out of the brace and crutches over the next six weeks. Four weeks post-operative a repeat radiograph showed no evidence of distraction of the patella and at this time quadriceps strengthening and knee ROM exercises were initiated. Eight weeks post-operative the patient was out of the brace and began active ROM exercises. Ten weeks post-operative treatment focused on quadriceps muscle strengthening. The patient is currently fourteen weeks out and is continuing to improve; current treatment focuses on lower extremity strengthening and increasing function. It is expected the patient will have the hardware removed once the fracture site has healed, and return to full activities of daily living six months postoperatively. **Uniqueness:**

According to the literature, patella fractures are rare but not uncommon following ACL reconstruction utilizing quadriceps tendon graft. This case is unique because the fracture occurred as a result of a tensile force at the knee and not direct contact, which is a common mechanism for acute patellar fracture in an athletic population. Additionally, the fracture was at the level of the bony defect resultant from the ACL reconstruction. **Conclusions:** In this case the individual sustained a noncontact patellar fracture approximately 7 months post-ACL reconstruction using quadriceps tendon autograft. In addition to integrity of the graft, the patient's strength, ROM and function; graft site healing should be taken into consideration when returning patients to full activity.

Isolated Grade II Posterolateral Corner Injury In A High School Football Player

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Background: We present the case of a conservatively treated isolated grade II posterolateral corner (PLC) injury in a high school football player. A previously healthy sixteen year old varsity running back with no prior history of lower extremity injury was tackled during a preseason scrimmage. When the tackle occurred, his right foot was planted on the ground, resulting in an external rotation and valgus force at the right knee. The athlete was able to limp off the field under his own power, however he presented to the certified athletic trainer with complaints of deep and aching pain (6/10) over the posterolateral aspect of his right knee. Physical examination revealed a mild joint effusion, decreased knee flexion, and point tenderness over the lateral tibial plateau, fibular head, and lateral collateral ligament. The patient's pain increased with flexion, varus stress, and weight bearing. Moderate (2+) laxity was noted with the varus stress test at 30° of knee flexion, and increased external rotation was noted with the Dial test at 30° of knee flexion. **Differential Diagnosis:** Lateral collateral ligament sprain, PLC injury, lateral meniscus tear, anterior/posterior cruciate ligament sprain, avulsion fracture of the fibular head, tibial plateau fracture. **Treatment:** The patient was managed on site with ice and compression. He was placed in a straight leg immobilizer and was given crutches for non-weight bearing ambulation. The patient was evaluated by an orthopedic surgeon two days after the initial injury. Radiographs were negative for fracture, while magnetic resonance imaging (MRI) revealed a grade II sprain of the lateral collateral ligament and popliteofibular ligament, as well as a bone contusion within the posteromedial tibial plateau. The orthopedic surgeon recommended conservative treatment which included partial weight bearing for four weeks in a DonJoy T-ROM brace allowing for 30°-70° of knee flexion followed by a five week course of physical therapy with the goal of regaining normal range of motion, strength, and neuromuscular control. **Uniqueness:** PLC injuries are relatively rare when compared to the other capsulo-ligamentous structures of the knee. These injuries are also rarely isolated (1.6%), and often occur with concomitant tibial plateau fractures (Segond fracture), avulsion fractures of the fibular head (arcuate sign), anterior and posterior cruciate ligament tears, peroneal nerve injuries, distal tears of the biceps femoris tendon, tears to the lateral head of the gastrocnemius, IT-Band tears, and knee dislocations. Injuries to the PLC are also commonly missed upon both physical examination and imaging, especially in the presence of concomitant injuries. Furthermore, although conservative treatment is often recommended for grade II PLC injuries, there is little published information on the long-term natural history, and there are no known reports on the natural history of isolated injury of individual components of the posterolateral complex. **Conclusions:** It is crucial that clinicians proceed with a high degree of suspicion when dealing with possible PLC injuries, especially in the case of grade III injuries. After 2-3 weeks the tissue becomes necrotic, and a primary acute repair is no longer possible. Additionally, unrecognized injuries to the PLC have been associated with a high incidence of ACL and PCL graft failures, and chronic injury can result in a high degree of disability. In this case the patient was cleared to return to full participation approximately

three months after the initial injury. He progressed through the start of basketball season without recurrence and only minimal symptoms. However, he still exhibits mild residual laxity with tibial external rotation. Although long term follow up is needed to fully assess the outcome, it appears that in this case, conservative treatment was successful in treating an isolated grade II PLC injury.

Median Arcuate Ligament Syndrome In A Collegiate Female Rower

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Background: We present a case of a median arcuate ligament syndrome (MALS) in a 20-year-old collegiate female rower. The purpose of this case report was to emphasize the diagnosis and treatment of this rare vascular disorder, in which the celiac artery was compressed by the median arcuate ligament as it passes through the diaphragm. The initial athletic training examination, after a race in March 2011, revealed severe lower abdominal pain and cramping, accompanied by nausea and lightheadedness. The athlete had no history of abdominal pain and her vital signs recovered normally following the race. At first, her symptoms were only triggered by racing, but after several months, even submaximal exercise provoked the symptoms. Due to the incapacitating severity of the symptoms, the athletic trainer referred her to the team physician. **Differential Diagnosis:** The athletic trainer's differential diagnoses included hypoglycemia, exertional heat illness, illiopsoas spasm, and possible ovarian cysts. **Treatment:** In April of 2011, within a week of the onset of her symptoms, the athlete was examined by her team physician. A comprehensive blood panel and urinalysis yielded normal results. Two weeks later, a CT angiograph revealed only a small ovarian cyst. The athlete was referred to a GI specialist who prescribed omeprazole and ordered an ultrasound of the liver and gall bladder. The ultrasound was unremarkable so he referred the athlete for a cardiac evaluation to rule out vasovagal syncope. The cardiac evaluation included an electrocardiogram, echocardiogram, and stress electrocardiograph, which revealed a benign mitral valve prolapse. At a follow-up visit with the GI specialist in July 2011, a duplex scan of the celiac and mesenteric arteries was unremarkable. An upper endoscopy, with biopsy, was also negative for H. Pylori. A magnetic resonance angiogram (MRA) of the abdomen revealed moderate narrowing of celiac artery, most likely related to compression by the arcuate ligament of the diaphragm. When the athlete reported for August physical exams, the team physician cleared her to participate as tolerated, but referred her to a vascular surgeon for a consultation. In December 2011, after reviewing her records and performing an examination, the vascular surgeon deemed the athlete a candidate for a laparoscopic release of the median arcuate ligament. In January 2012, the procedure was performed and the patient was released from the hospital the following day. The team nutritionist, athletic trainer, and surgeon educated the athlete on optimal food choices before, during and after exercise. During the four weeks post-operative, the athletic trainer guided her through a gradual return to rowing. For the first 2 weeks post-operative, she was restricted to submaximal, low-impact cardiovascular exercise. For the next two weeks, she performed higher-impact cardiovascular exercise and began submaximal weight-lifting. After 4 weeks, she began gradual progression on the rowing ergometer, increasing exercise duration before increasing intensity. The athlete returned to racing 8 weeks after the surgery. Our athlete has had to withhold herself from several races since the surgery, but is currently able to race without recurrence of symptoms. **Uniqueness:** In 10-24% of people, the median arcuate ligament can compress the celiac artery. CT angiography and MRA is able to diagnose the compression of the

celiac artery. The significance of this compression is a source of controversy in the literature, especially given the high incidence of this finding in otherwise asymptomatic individuals. **Conclusions:** Athletic trainers often evaluate abdominal pain, nausea and lightheadedness. We should be aware that MALS can be a source of these symptoms. Athletic trainers are qualified to guide an athlete through a gradual return to play following laparoscopic release of the median arcuate ligament.

Recurrent Anterior Cruciate Ligament Deficiency In The Varus Aligned Knee Of A Multi-Sport Athlete

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Background: A 33 year old male recreational athlete presented with left knee instability in February 2011. Patient's history involved multiple anterior cruciate ligament (ACL) injuries initially from a snowboarding accident approximately twelve years prior. In 2001 he underwent primary ACL reconstruction with patellar tendon autograft and partial medial meniscectomy. A revision ACL reconstruction with patellar tendon allograft was performed 4years later. Both procedures were performed at outside facilities. In February 2011, he presented with a chief complaint of popping, catching, and instability following a work-related injury. The patient ambulated with antalgic gait assisted by a custom hinged knee brace. Focal exam revealed no deformity, lesions, erythema or ecchymosis. Patient was non-tender to palpation and presented with equal patellar mobility and range of motion of 0/0/125 degrees. Patient had positive Lachman and anterior drawer testing with negative meniscal findings. After initial evaluation, a revision ACL reconstruction was performed. At 7months, he returned to full activity with a functional ACL brace. Approximately 10months after surgery, the patient experienced left knee instability followed by a "pop" sensation. The patient returned for evaluation where physical exam findings, included left knee effusion with positive Lachman and anterior drawer tests, consistent with an ACL tear. **Differential Diagnosis:** ACL graft insufficiency, graft tunnel misplacement, lack of graft incorporation, meniscal pathology, varus alignment. **Treatment:** Initial radiographic imaging including AP/Lateral/Sunrise views revealed good joint space and alignment and evidence of two previous ACL reconstructions with tunnels and screws. Outside magnetic resonance imaging(MRI) dated February 2011 revealed ACL repair with graft failure, probable post-meniscectomy without tearing of the root of the medial meniscus, degenerative joint disease of medial and patellofemoral compartments, and small flap tear of central trochlear groove. Initial surgical intervention involved revision ACL reconstruction with Achilles tendon allograft, tunnel bone grafting and removal of hardware. Following re-injury, longstanding radiographs demonstrated varus alignment of left lower extremity. Diagnosis included failed ACL reconstruction secondary to varus alignment of the left lower extremity warranting additional surgical intervention. A staged procedure involving chondroplasty, hardware removal, allograft bone grafting, and opening wedge high tibial osteotomy(HTO) was performed to correct alignment, to be followed by revision ACL reconstruction with allograft approximately 6months later. **Uniqueness:** A direct relationship has been found to exist between lower extremity varus alignment and anterior cruciate ligament tension. It is recommended that varus alignment be examined in patients, especially with recurrent ACL failures, as tension across a malaligned knee may cause graft stretching and failure regardless of graft choice. **Conclusions:** This athletic patient underwent multiple left knee procedures to reconstruct the integrity of his ACL. He experienced three failed reconstructions prior to assessment of varus alignment. At 5months status post HTO procedure to correct alignment the patient is progressing through physical therapy with no complications. He continues to demonstrate positive findings for

ACL deficiency and is scheduled to proceed with revision ACL reconstruction. Recognition and correction of varus alignment is crucial prior to proceeding with a ligament reconstruction, in particular in a young athletic population where varus alignment combined with ACL deficiency can be a common finding. With the combination of this staged procedure, the sports medicine team hopes to return the patient to regular athletic activities and prevent the need for further surgical intervention. It is for these reasons that sports medicine professionals should be aware of the reasons for primary ACL reconstruction failure and be able to provide a full examination including radiographic assessment to address potential malalignment.

Athletic Training Considerations In A Below The Knee Amputee In Football And Wrestling: A Case Report

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Background: A 15-year-old male with a right below the knee amputation (BKA) presented to the AT staff to participate in junior varsity football and wrestling. The patient had previously participated in youth sports with few to no limitations. At the start of the academic year, the AT staff were required to assess the Americans with Disabilities Act (ADA) guidelines and the North Carolina High School Athletics Association (NCHSAA) rules and regulations regarding athletic participation for individuals with prosthetics. Care and management of the prosthetic appliance and limb were also investigated. **Differential Diagnosis:** Choke syndrome, Contact Dermatitis, Epidermal Cyst, Maceration, Tinea Infection. **Treatment**: The patient was able to participate throughout the interscholastic football and wrestling seasons with minimal complications. At the start of each football competition, the AT staff provided the officiating team with NCHSAA required documentation of medical necessity and demonstrated adequate padding for the rigid metal hinge and post at the leg and foot interface. Prior to and during the wrestling season, the patient was required to comply with NCHSAA weight certification standards with and without the prosthetic appliance. In active individuals with prosthetic lower limbs, several dermal conditions may also present and require treatment from the AT. Complications such as choke syndrome, contact dermatitis, tinea infections, and skin maceration often occur as are result of excessive compression, moisture, friction, and infection. **Uniqueness:** It is estimated that among the 21 million athletes with disabilities, 5-10% have a physical disability or physical impairment in which Athletic Trainers must be able to provide sideline care. As athletic trainers broaden their employment settings, the possibility for an athletic trainer working with a patient with a prosthetic is more common. Similarly, as large numbers of military veterans return from combat operations abroad with amputations, these individuals will seek out opportunities for competitive participation and physical activity. ATs should be able to provide each patient with the necessary care and recognize when referral is necessary. ADA and NCHSAA regulations provide guidance to the practicing AT on how to care for these unique patients. **Conclusions:** It is important as an athletic trainer to provide compassionate and appropriate care to all athletes. For an athlete who has a BKA prosthetic or any other prostheses it is important to know the ADA regulations and accommodations, understand how a prosthetic is designed, fit, and how to repair issues. The athletic trainer must also be able to recognize potential complications for prosthetic use. Finally, the athletic trainer must establish relationships with the patient, parent, coaches, primary care giver, and the prosthetist.

Left Anterior Knee Pain In A Collegiate Women's Track And Field 400-m Hurdler

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Background: A 19-year-old female collegiate 400-m hurdler presented with left anterior knee pain over a two week period following the end of her freshmen year of competition. She complained of pain and swelling subsequent to intense workouts during the peak of her outdoor season. For the past five years, she has experienced intermittent knee pain over her patellar tendon throughout the course of her training and competitions. **Differential Diagnosis:** Patellar tendinitis, patellar tendon strain, tibial osteochondral defect, arthritis, medial meniscal tear, inferior patellar calcification. **Treatment:** Following her season, the athlete was referred to the team orthopedic physician. Radiographs were negative for fractures and no evidence of arthritis was found. The physician's diagnosis was mild patellar tendinitis. The athlete was administered a course of oral anti-inflammatories with continued rest and rehabilitation for three months. Two weeks into her return to fall pre-season training, she continued to experience significant anterior knee pain and was referred for diagnostic musculo-skeletal ultrasound images. Ultrasound images revealed two significant tears in her patellar tendon. Due to continued pain and failed conservative treatment, she was referred for platelet-rich plasma (PRP) treatment. Three weeks later the athlete had her first PRP treatment administered. Following the injection, she was non-weight bearing for the first forty-eight hours. For the initial four weeks, no non-steroidal anti-inflammatory drugs (NSAID's) were ingested, and ice was only applied for ten minutes every hour to reduce the risk of impeding the healing process. She progressed through range of motion and stretching exercises for the initial two weeks then began to swim and bike. By week four strengthening exercises were implemented. At week five, prescription NSAID's were administered and strengthening exercises were progressed. At the start of the indoor season, additional ultrasound images confirmed marked improvement with one of the two tears; however the other tear was still present. As a result, her second PRP treatment was administered. The same post treatment protocol was followed. At week four, physical therapy (PT) was ordered three times per week for ten weeks with the team physical therapist. Two months after PT, MRI and ultrasound images showed complete resolution and she has since returned to full participation. **Uniqueness:** This case is unique because the athlete had significant intermittent knee pain for five years. Current literature suggests that following multiple PRP injections for tendinopathies, individuals return to full activity within three to six months. This athlete returned to a highly trained, collegiate level within ten months and is currently asymptomatic. The majority of studies have suggested that PRP treatments are beneficial and have a positive influence in the treatment of patellar tendinopathies. This case is unique because PRP evidence based research is still in its infancy and is a topic of interest in the medical field. This case provides additional evidence to support the use of PRP treatment for patellar tendinopathies. **Conclusions:** A collegiate female 400-m hurdler presented with anterior knee pain at the end of her freshmen season of competition. Ultrasound images confirmed two significant tears in her patellar tendon. The compromised patellar tendon was treated with two platelet-rich plasma treatments, NSAID's, and PT. This case is significant because in less than ten months the athlete is completely asymptomatic and has returned to full team participation, despite being symptomatic for the previous five years. More research is still needed to determine an appropriate number of treatments to be administered, the time frame in which the treatments should be administered, and the long term efficacy of PRP therapy.

Medial Knee Pain In An In-Season Collegiate Men's Soccer Player

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Background: A 21 year old male collegiate soccer player presented with left knee pain following a game. His initial pain was felt after changing direction from forward to backward running. He complained of pain along the medial joint line and posterior medial aspect of his knee with forced knee flexion. Clinical examination yielded a positive McMurray and bounce home test. The athlete had no prior history of left knee injuries. **Differential Diagnosis**: Medial meniscal tear, Medial Collateral Ligament sprain, femoral bone contusion, tibial plateau contusion, femoral osteochondral defect (OCD). **Treatment**: Possible meniscal pathology was confirmed by the team physician and the athlete was referred for diagnostic imaging. MRI results revealed loose chondral fragments and 1 x 1.5 cm acute lateral femoral OCD of the left knee. The loose bodies were removed arthroscopically and the OCD was repaired. Microfractures were performed on the lateral femoral condyle to promote healing of the OCD. Following surgery, the athlete was strictly non-weight bearing for one week. Range of motion and open chain strengthening exercises were implemented immediately following surgery. The athlete began partial weight bearing in week two, and reached full weight bearing very quickly. Sport specific activities were performed after four weeks. The athlete reached full participation five weeks post-surgery. Rehabilitation and treatments were continued through the end of his season. He was able to complete the remainder of his competitive season with minimal symptoms. **Uniqueness**: The athlete presented with medial knee pain, yet the injury occurred on the lateral aspect of the knee. Initial findings indicated meniscal symptoms; however the injury occurred to the lateral femoral condyle. This case is also unique because of the timeline to full participation. The patient was able to return to full athletic competition in five weeks. Current research has suggested that typical return to competition in high-level male soccer athletes following microfracture repair of a 2 cm2 OCD is eight months. The fact that his OCD was relatively small, and that only a few microfractures were performed is the cause for his uniquely quick recovery. Current research has also suggested that frequency of OCD on the lateral femoral condyle is fairly low (7-20%). This poses the question of whether size or location of an OCD repaired with microfracture is more important to recovery time. **Conclusions**: A collegiate male soccer player who presented with possible medial meniscus pathology was found to have loose chondral fragments and a lateral femoral OCD of the left knee. The injury was repaired arthroscopically and rehabilitation began immediately. He was able to complete the remainder of his competitive season with minimal symptoms; however, following the season, the athlete experienced lateral knee pain. This is consistent with research that suggests microfracture repair may cause clinical deterioration over time. This case is significant because of the presentation of initial symptoms, and despite suffering a potentially season ending injury, a high-level athlete returned to competition during the same season. He completed his collegiate career and has now continued with recreational participation.

Osteochondroma Of The Scapula: An Unusual Cause Of Unilateral Scapular Winging In An Overhead Athlete

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Background: A 15-year-old male high school overhead athlete reported to his certified athletic trainer with a chief complaint of left periscapular pain and deformity. He was a two sport athlete, playing basketball and football quarterback. He reported no incident of injury or known history of upper extremity or back injury. The athlete was aware of the mass for several years but noted a recent increase in size and irritation. He started having pain with weight training activities, such as overhead press, lat pull downs and shoulder shrugs. He denied recent illness or constitutional symptoms. He complained of pain that is sharp in quality and intermittent in nature, occurring with reaching and overhead activities. Range of motion was full with some scapular crepitus. An evaluation revealed unilateral scapula winging with a palpable mass on the left side. The athlete was referred to team physician for further evaluation. **Differential Diagnosis:** Differential diagnosis includes: brachial plexopathy, long thoracic nerve palsy, spinal accessory nerve palsy, Parsonage-Turner syndrome, cervical radiculopathy, neoplasm. **Treatment:** Physical examination by physician revealed severe scapula winging on the left and a palpable left shoulder mass that was supple and non-adherent to the thoracic ribs. There was no axillary lymphadenopathy. Diagnostic x-rays confirmed an abnormal calcification of the left thoracic. An MRI was ordered and consultation with orthopaedic tumor specialist was obtained to rule out malignancy. MRI scan revealed a well circumscribed 2cm x 2cm exostosis on the anterior

aspect of the lower body of the scapula. The lesion was determined to be an osteochondroma with a large multi-septated cystic collection with prominent subscapular bursa that measures 12cm X 7.5cm x 18cm. Treatment options were discussed with parents and athlete with surgical excision encouraged. Surgical excision was carried out with an incision over the medial scapula with lower trapezius, latissimus dorsi, and rhomboids dissected. The medial scapula was retracted and the mass was sharply excised. Rehabilitation began at one month status post and focused on periscapular and rotator cuff strengthening. Return to play criteria including pain-free overhead ROM of motion, periscapula and rotator cuff strengthening was met at four months. A scapulothoracic stabilization brace (used for proper scapular retraction to improve posture alignment, scapular function, and reduce pain) was prescribed for early return to play. The athlete has made a full recovery and has returned to full athletic activity, playing at starting quarterback position in the fall. **Uniqueness:** Scapula winging is a common finding in the evaluation of an overhead athlete with shoulder pain. The finding of unilateral scapular winging should alert the practitioner/clinician to a differential diagnosis of neuropraxia, trauma, and neoplasm. **Conclusions:** This case outlines a rare cause of unilateral scapula winging in an overhead athlete. Osteochondromas are benign lesions that usually form on long bones. Osteochondromas are the most common benign lesion on the scapula and although rare (3-5% of all cases), should be considered in cases of unilateral scapula winging when there is no definitive mechanism of injury. Full recovery and return to competitive overhead sports can be achieved after successful surgical excision and rehabilitation of the periscapular musculature.

Os Acromiale In Dominant Shoulder Of An Overhead Athlete

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Background: An 18 year old, female, freshmen Division 1 softball catcher with no previous history of injury to either shoulder prior to entering college reports to the athletic trainer with complaints of anterior shoulder pain. Due to the increases in activity from high school to collegiate athletics the athlete began to experience anterior shoulder pain on her dominant (right) shoulder. The athlete reported increased pain upon throwing, especially long distances. Examination revealed tenderness to palpation over the right acromion process. The acromioclavicular compression test as well as the Hawkins sign were both positive for pain. Internal and external rotation shoulder range of motion was limited due to pain. When asked to rate her pain on a scale from 1 to 10, the athlete reported a 7 out of 10. All other range of motion, special tests, and manual muscle tests were within normal limits. **Differential Diagnosis:** Impingement syndrome, rotator cuff pathology, acromioclavicular joint sprain, biceps brachii pathology, scapular dyskinesis, labral pathology, clavicle fracture, thoracic outlet syndrome, directional instability, or bony pathology. Treatment: The athlete was referred to the team physician where an evaluation resulted in the diagnosis of impingement syndrome. The team physician however, ordered an x-ray to rule out any other pathology. The x-ray revealed an os acromiale. Os acromiale is found when one or more of the three growth plates in the acromion process have not closed. The athlete was given non-steroidal anti-inflammatory drugs (NSAIDs) and a corticosteroid injection in order to decrease the pain and inflammation present in the area. The injection was given at the site of pain which was located at the acromioclavicular joint. After 4 days of rest the athlete was prescribed a shoulder rehabilitation program. The program focused on scapular muscle strengthening as well as an overall shoulder muscle flexibility program in an effort to take the pressure off the anterior aspect of her shoulder. The shoulder program consisted of multidirectional band work, horizontal flies, internal and external rotation exercises, raises in the scapular plane, and scapular squeezes. Additionally, modalities such as ice, compression, ultrasound, and electric stimulation were prescribed. Although this particular athlete was allowed to rest while the injection took effect, she was never fully with held from play. The athlete was instructed to decrease the weight she was lifting to her tolerance and her number of throws in practice were limited. As her strength increased and pain decreased, the amount she was allowed to lifted and throw increased accordingly. The athlete was fully able to return to play pain free after 3 months. **Uniqueness:** Os acromiale is only present in eight percent of the population and within that eight percent, 33 percent have bilateral os acromiale. It is also reported to be more prevalent in males than females. Although it is unknown if this athlete has bilateral os acromiale, the small percentage of female athletes that present with this pathology provides evidence to the uniqueness of this case. **Conclusion:** According to current research, the majority of anterior shoulder pathologies can be treated by correcting scapula deficiencies. In this particular case, using NSAIDs and a cortisone injection provided the athlete with significant pain relief which enabled her to participate in rehabilitation. Within a month of diagnosis, the strength of the athletes'

posterior musculature had increased and her anterior shoulder pain had significantly decreased. This case provides further support that even with a bony deformity, such as os acromiale, that results in significant anterior shoulder pain, implementing a scapular strengthening program aids in rehabilitating the athlete back to pain free return to play.

Left Shoulder Pain In High School Athlete

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Background: A 17 year old right handed high school football player presented to the athletic training room with diffuse left shoulder pain. He noted discomfort superior to his clavicle with radiation into his upper trapezius and deltoid. He could not recall a specific mechanism of injury but stated discomfort began during tackling drills. Due to the significant pain, the athlete noted difficulty raising his arm above shoulder level and taking a deep breath. He denied previous history of injury to the shoulder, numbness, tingling, or neck pain. On examination the patient was tender superior to the proximal left clavicle and within the mid-belly of the trapezius and sternocleidomastoid. Shoulder ROM was limited to 90 forward flexion and 90 abduction secondary to pain. Neck ROM was antalgic to left lateral bending but otherwise full. Strength within the shoulder was antalgic but full and he had preserved strength and sensation throughout the remainder of the left upper extremity. **Differential Diagnoses:** Soft tissue contusion, clavicle fracture/ contusion, acromioclavicular sprain, shoulder capsular sprain, rib fracture. **Treatment:** Initial treatment consisted of symptom management. The athlete was restricted from sport specific activities, utilized over the counter anti-inflammatory medications for pain relief and extensively iced the shoulder. With a lack of improvement, he was seen by the team physician. Plain radiographs were pertinent for a non-displaced fracture of the left first rib. The athlete was placed in a sling with instructions for non-weight bearing of the left upper extremity and restricted ROM. He was held out of all contact activities for an anticipated 10-12 weeks. Physical therapy was initiated after 6 weeks of restricted motion and non-weight bearing. The athlete was seen every 2 weeks for repeat rib radiographs. Callus formation was noted after 1 month and healing progressed thereafter. At 6 weeks the patient began conditioning activities, progressed to weight lifting after 8 weeks and released for full contact after 10 weeks. At that time, he had full pain free ROM and strength. Therapy was continued for progressive strengthening. The patient missed the remainder of the football season but was cleared for wrestling activities. **Uniqueness:** The case denoted a rare presentation of a first rib fracture with symptoms that mimicked a clavicle or AC joint injury. The patient's symptoms were non-specific, and without a given mechanism of injury, could have been attributed to numerous soft tissue and bony shoulder pathology. **Conclusion:** The athlete responded well to conservative management. He returned to wrestling activities initially at full participation but activity level had to be scaled back due to pain recurrence. He will be gradually progressed through pain free activity with a return to full participation in another 2 weeks. He denied additional acute injury and repeat radiographs noted a completely healed left first rib fracture with adequate callus formation. Final evaluation indicated a non-tender shoulder with symmetric ROM and strength between the uninvolved dominant and involved non-dominant extremity. Although rare, the diagnosis of a first rib fracture requires a heightened suspicion from medical professionals. Prolonged conservative management can yield satisfactory results and return to previous level of activities.

Suprascapular Neuropathy In A Collegiate Baseball Pitcher: A Case Study

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Background: A healthy 19-year-old male in his first year as an NCAA Division I baseball pitcher complained of pain in his right anterior and posterior shoulder that he rated as a 7-8/10. Pain occurred on 5/11/10 after pitching 4 innings. The athletic trainer's initial physical examination revealed point tenderness over the rotator cuff musculature, full AROM, and weakness (4/5) with manual muscle testing in flexion, adduction and external rotation. Resisted external rotation specifically reproduced the pain. **Differential Diagnosis**: Rotator cuff pathology, suprascapular neuropathy, labral pathology, subacromial impingement, brachial plexopathy, C5-6 radiculopathy, quadrilateral space syndrome, and space occupying lesion. **Treatment**: The team physician's examination on 5/12/10 identified severe atrophy of the infraspinatus with scapular dyskinesis. The atrophy was attributed to a suprascapular nerve compression in the spinoglenoid region, which was thought to be from a ganglion cyst. An x-ray showed no abnormalities, and an MRI revealed no space occupying lesion, rotator cuff or labral pathology. A decreased neuromotor signal in the suprascapular nerve was confirmed by an Electromyography (EMG) test. Surgeons who specialize in baseball injuries were consulted on the case, and they collectively recommended a 6 month period of rest, rehabilitation, and a slow throwing progression. The athlete improved steadily, and was cleared for full participation on 12/7/10 after an improved EMG test and successful bouts of pain free pitching at full strength. During the spring season, pain and atrophy returned, which was confirmed by EMG testing on 3/18/11. At this time surgery was recommended, but the athlete opted to try Accelerated Recovery Performance (ARP) wave treatment instead. After 5 weeks of treatment, the symptoms remained unresolved, and on 5/10/11 the athlete underwent surgery to decompress the suprascapular nerve. Nine months of rehabilitation, including scapular correction, eccentric exercise, and throwing followed the surgery, and he returned to pitching and all team activities on 1/9/12. After 7 weeks of successful pitching, complaints of scapular tightness began. Prolonged tightness led to a follow up shoulder MRI on 3/24/11, which was deemed normal. Acupuncture, suction cup, and massage therapy were attempted to relieve the tightness with limited success. Lack of relief led to a CT scan of the right shoulder on 4/6/12 to rule out quadrilateral space syndrome. The scan revealed a possible occlusion of the suprascapular artery, potentially causing thoracic outlet syndrome during throwing. Upon consulting a vascular specialist, it was concluded that thoracic outlet syndrome was not the cause of the symptoms. Referral to a physician with several years experience in major league baseball did not uncover any new evidence. To rule out a cervical radiculopathy, a neck MRI was performed on 4/23/12 that showed no irregularities. Symptoms again improved with rest, and a throwing program was initiated the following fall on 6/18/12. This irritated the athlete's right latissimus dorsi muscle. As a result the athlete consulted a chiropractor, who added supplemental K-Laser treatments to the existing rehabilitation exercises. By slowing the athlete's progression and modifying mechanics, he continues to improve with minor setbacks. To date the athlete is on schedule to participate in the 2012-2013 season. **Uniqueness**: This case is unique because the diagnosis of suprascapular neuropathy associated with repetitive overhead throwing is uncommon, and easily misdiagnosed. This can lead to improper rehabilitation, which may exacerbate the problem. **Conclusions**: Evidence suggests that suprascapular neuropathies in overhead throwers can be complex and potentially misdiagnosed due to a similar presentation as common rotator cuff tendonopathies. Clinicians should be aware that atrophy of the infraspinatus may be caused by a compression of the suprascapular nerve. This case study hopes to improve the effectiveness of clinicians in diagnosing and treating suprascapular neuropathies.

Wrist Pain In A Female Intercollegiate Javelin Thrower

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Background: A 20 year-old, 64cm, 72.6kg female javelin thrower presented with right, dull, radiating mid-forearm pain with crepitus secondary to repetitive stress. She reported being able to perform ADL, but unable to perform unrestricted sport activities. Pain quotient was 5/10 at rest, 8/10 with activity, and 6/10 after activity. Pain was alleviated by rest and aggravated by wrist flexion and extension. Initial examination revealed posterolateral wrist and forearm swelling and palpabable tenderness. ROM was WNL, but forearm pronation and wrist and thumb extension were painful. MMT revealed pronation and wrist and thumb extension at 4/5. Special tests demonstrated no ligamentous, vascular, or neurological pathology. The patient's previous medical history was significant for right wrist sprains at 11 and 14 years old, and a fractured right ulna at 13 years old. At age 18, she reported dull pain, crepitus, and swelling in her wrist, and a noticeable forearm deformity, but was non-compliant to treatment. Related history also included an unknown elbow and forearm pathology with similar symptoms in the forearm, which were treated with rest, cryotherapy, and therapeutic exercises. The elbow pathology resolved, but the forearm pain persisted. The patient self referred to a chiropractor twice per week and was treated with Graston tools, which caused swelling, bruising, and pain. She was referred from the chiropractor to an orthopedist who ordered radiographs, which were unremarkable, and a corticosteroid injection that did not provide relief. **Differential Diagnosis:** inflamed extensor reticulum, radial stress fracture, radial neuritis, extensor carpi ulnaris tendinopathy, pronator teres tendinopathy, De Quervain tenosynovitis, and intersection syndrome. **Treatment:** After initial evaluation, the patient received conservative treatment encompassing massage and a wrist orthosis limiting wrist and thumb extension and was referred to the team orthopedist. The team orthopedist definitively diagnosed the patient with intersection syndrome. Based on his clinical examination, he recommended she remain in the orthoses and take two months off from throwing. He also prescribed cryotherapy, compression, elevation, and NSAID therapy for seven days. Status-post one week, the patient began a rehabilitation program emphasizing further pain and swelling reduction and restoring soft tissue mobility and strength of the wrist and thumb. The rehabilitation program consisted of physical agents to decrease inflammation and therapeutic exercises focusing on fine motor control and dexterity, and eccentric strengthening to increase grip and twisting strength. Status-post eight weeks, the patient was cleared for conference championships and was able to throw with minimal discomfort. She continues to manage any post-activity inflammation with cryotherapy. **Uniqueness:** Intersection syndrome is unusual with an incidence rate of less than 1% of all forearm, wrist, and hand injuries. The condition is primarily seen in individuals who perform repetitive wrist actions during occupational activities such as raking and shoveling where excessive grasping, wringing, and twisting of the wrist occur. Intersection syndrome is rarely studied in athletic training education curricula. **Conclusions:** Intersection syndrome is an inflammatory condition that occurs at the intersection or crossover point of the first extensor (extensor pollicis brevis, extensor carpi radialis longus) and the second extensor (extensor carpi radialis longus, brevis) compartment and can easily be clinically misdiagnosed. The condition is caused by excessive friction between the two compartments or entrapment from stenosis. It presents with pain, swelling, and creptius in the distal dorsoradial forearm. Intersection syndrome responds favorably to conservative management within eight weeks. This includes modifying sport activities to decrease stress on the wrist and forearm, physical agents, and therapeutic exercises to reduce pain and swelling, which improve tendon gliding between compartments.

Conservative Treatment For Osteolysis Of The Distal Clavicle And An ALPSA lesion In A National Circus School Athlete

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Background: We are presenting the case of a 24 year old male circus student from l'École Nationale de Cirque with a history of coracobrachialis tendonitis. The student majors in straps which is an acrobatic specialty consisting of two thin parallel straps several meters in length, which he rolls and unrolls using the wrists and arms to execute held poses, while being suspended. The athlete started to feel pain at a particular performance where he was lifting people onto the shoulders of other performers. During this performance the tower is not stable and the weight is not distributed evenly. The athlete was standing with knees fully flexed, holding another artists leg, one hand at the end of his calf and the other just below his knee. His elbows were flexed and abducted due to the lack of space. He was assessed with having biceps tendonitis and prescribed rest. After 6 weeks of rest there was no change in pain. His first assessment back revealed poor posture including rounded shoulders. Right shoulder ROM; extension 60° with 1/10 rating for pain, flexion 185° (2/10), ABD 185° pain-free, ADD 0° (3/10), internal rotation 95° (4/10) and external Rotation 80° pain-free. Manual muscle testing of the mid and lower traps, rhomboids, and rotator Cuff were weak (3/5) and pain-free. Coracobrachialis had 5/5 strength with 1/10 for pain. Special Tests; impingement and speed's test were positive. After two weeks of strengthening exercises, laser treatments, and decreased activity there was limited success. He was then referred to a sports doctor who recommended x-rays and an arthro-MRI. **Differential diagnosis:** Biceps long head tendonitis, supraspinatus tear, rotator cuff impingement. **Treatment:** The MRI results indicated the distal end of the clavicle and to a lesser extent, the medial acromion were irregular from bone resorption indicating a post traumatic osteolysis. In addition there was a soft tissue mass at the AC joint. Moreover there was a high signal intensity of the bone marrow suggesting edma formation of the distal clavicle. Also, the antero-inferior labrum appeared detached from the bone of the glenoid but remains attached distally to the periosteum indicating an Anterior Labral Ligamentous Periosteal Sleeve Avulsion (ALPSA) Lesion. We started conservative treatment by addressing his poor posture including scapular stability exercises and strengthening exercises (trapezius, rhomboids, and rotator Cuff). We released tight muscles (trapezius, rhomboids, rotator cuff), and performed AP gleno-humeral glides. We used K-tape to maintain his scapulae in a retracted position, which the athlete indicated was effective in reducing his pain. After 3 weeks of moderate success, the athlete received a cortisone injection and felt significantly better. **Uniqueness:** Trauma and repetitive injuries are often the cause of post-traumatic osteolysis of the distal clavicle, and often occurs in weightlifters with pain during shoulder elevation and adduction. This case involved a similar mechanism in a circus performer who performed his straps routine with his body weight. ALPSA lesions were first described in 1993 as detached capsulolabral complexes which healed medially on the scapular neck. A history of multiple dislocations is usually present in ALPSA lesions, but not in this case. When conservative treatments fail, operative treatments are often considered however, the prognostic implications of arthroscopic repair are unclear. Additionally, the recurrence of instability after repair for an ALPSA lesion is twice as high as the recurrence after repair of a Bankart lesion. **Conclusion:** Circus athletes have extreme flexibility making the assessment difficult. Some of the performances require weight bearing activities and may not be easily recognized as typical mechanisms of injury. More studies are needed on this type of athlete and non-operative treatment for osteolysis and ALPSA lesions.

Left Upper Extremity Swelling In A Collegiate Football Punter

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Background: A 22 yr old male, Division I collegiate football punter (5'8', 191 lbs), reported to the athletic training staff on Monday following a game. The athlete was not a member of the travel squad and had participated in a non-travel training session on the previous Friday. Athlete reported feeling an "unusual tightness" in his left upper extremity during the military press which had not subsided. The athlete had no previous history of upper extremity trauma and no relevant medical history. Physical examination revealed slight edema about the entirety of the left arm with mild hyperemia but no true ecchymosis. He reported no discomfort. The skin of the left upper extremity was free of lesions and completely intact, but clearly distended. Neurological evaluation revealed slightly reduced sensation about the entire left upper extremity but no myotomal weakness. He had normal and equal pulses bilaterally, and no lymphadenopathy. **Differential Diagnosis:** Thoracic outlet syndrome (TOS), deep vein thrombosis (DVT) or embolism, arterial or venous aneurysm, superficial thrombophlebitis, infection, musculotendinous rupture. Treatment: The athlete was evaluated by a team physician who ordered an X-ray to rule out rib-implicated TOS, which it did. He was referred for an ultrasound the next day which demonstrated no evidence of DVT. An MRI was obtained which demonstrated no evidence of DVT. During this time, the athlete reported an increase in his upper extremity tightness. Additional physical examination revealed strength deficits and noticeable discoloration ("mild purplish hue") about the arm. Due to the persistence of his symptoms, an MR arthrogram was obtained. The MRA was unremarkable, but was documented as "inconclusive" due to the fact that the subclavian vein was not evident. A venogram was then ordered which revealed a 5-7 cm fixed occlusion of a segment of the subclavian vein with collateral formation beginning and reconstituting the brachiocephalic vein indicating that the occlusion had been present for at least one month. Treatment was initiated the same day and consisted of thrombolysis via interventional radiology with Heparin and TPA infusion at 1 mg/hour for 24 hours. The next day a 10 cm x 4 cm balloon was inserted into the subclavian vein which yielded an excellent final angiographic result. However, it was noted that the vein was likely to re-occlude due to first rib pathology. The athlete was prescribed a regimen of Coumadin and Lovenox. Due to the likelihood of recurrence, the athlete was referred for left transaxillary rib resection. The athlete was cleared for full activity approximately 5 weeks following the rib resection, at which point the Coumadin was discontinued. The athlete had no incidence related to the pathology upon returning to his normal activity regimen. **Uniqueness:** Paget-Schroetter Syndrome (PSS) is a rare presentation of upper-extremity DVT, occurring in approximately 1-2/100,000 persons per year. As in this case, patients are commonly without previously recognized pro-thrombotic risk factors. PSS typically manifests in the dominant extremity of the patient, which was not true in this case. Based on the amount of collateral circulation that had developed, it appears that the occlusion had been present for a minimum of one month. The ability of the athlete to lift weights with the same intensity over the course of the season without symptoms makes this case unique. It is also interesting that numerous diagnostic tests did not reveal the pathology.

Conclusions: Although a rare pathology, PSS carries the potential of significant morbidity and potentially fatal complications such as post-thrombotic syndrome and pulmonary embolism. Therefore, it is imperative that athletic trainers recognize the signs and symptoms of PSS to facilitate appropriate and timely referrals, and remain diligent until a pathology is detected.

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