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Take this *Supplement* to Houston 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 2017 NATA Clinical Symposia & AT Expo in Houston, TX as part of the NATA Foundation Free Communications Program.

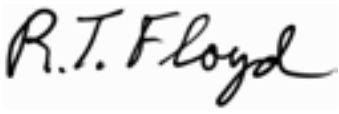
The Free Communications Program provides certified athletic trainers, students and other healthcare providers an opportunity to present and learn about the latest in athletic training research. Research is presented in oral and poster formats and includes general research, NATA Foundation-funded research, 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 Convention in Houston 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 150.

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,



R. T. Floyd, EdD, ATC

President, NATA Research & Education Foundation

Scott Sailor, EdD, 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 Velma Meza, Shelley Tims, NATA Foundation Director 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 for their long hours of abstract reviews and creativity in developing this year's Free Communications program. The Free Communications subcommittee members are:

Michelle Boling, PhD, ATC;
Steven Broglio, PhD, ATC;
Thomas Buckley, EdD, ATC;
Kenneth Cameron, PhD, MPH, ATC;
Jeff Driban, PhD, ATC, CSCS;
Kellie Huxel-Bliven, PhD, ATC;
Jennifer Earl-Boehm, PhD, ATC;
Blaine Long, PhD, AT, ATC;
Stephanie Mazerolle, PhD, ATC;
Brendan McDermott, PhD, ATC;
Sara Nottingham, EdD, ATC;
Erik Wikstrom, PhD, ATC, LAT
Cathleen Brown Crowell, PhD, ATC

We also acknowledge the unwavering support and guidance from Shelley Tims and RT Floyd, EdD, ATC, CSCS and the rest of the Foundation staff. I also specifically recognize Velma Meza who works tirelessly behind the scenes to assure a successful program each year. 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*. To further improve the process, we appreciate the feedback we have received from authors, and suggestions are always welcomed and discussed in committee meetings.

We look forward to seeing you in Houston. Please take the opportunity to attend the Free Communications Best Practices 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,

Joseph M. Hart, III, PhD, ATC
Vice Chair for Free Communications
NATA Research & Education Foundation Research Committee

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Awards

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The Medal for Distinguished Athletic Training Research

Darin A. Padua, PhD, ATC
University of North Carolina at Chapel Hill

Darin Padua's passion for athletic training and his humility despite his many accolades are clear. His hard work and dedication to always pursuing more in his career have led him to the Medal for Distinguished Athletic Training Research.

Padua got his start in athletic training through an introductory sports medicine course taught by Dennis Goebel, MA, ATC, at the College of the Sequoias in Visalia, California. He began assisting Goebel with prepractice treatments as an intern. Recognizing his enthusiasm for athletic training, Padua transferred to San Diego State University's well-regarded athletic training education program. Here, his interest in the academic side of athletic training began. Still, he pictured a future as a clinical athletic trainer. He received the Professional Football Athletic Trainer's Society Ethnic Minority Scholarship, which allowed him to assist during training camp with the Oakland Raiders. He credits this experience with giving him the confidence to work at a high level of athletic training.

However, he desired more educational and clinical experience, so he pursued a master's degree at the University of North Carolina at Chapel Hill, where Kevin Guskiewicz, PhD, ATC, FNATA, FACSM, introduced Padua to research in the area of concussion. Padua obtained his doctorate at the University of Virginia, where he met Kevin Granata, PhD, a biomedical engineer who was trying to understand anterior cruciate ligament injuries from an engineering perspective—examining mechanical properties, muscle stiffness, and other biomechanical factors. To this day, Padua speaks with fervor about the value of the biomechanical perspective when studying injuries and understanding deficits in motion.

Padua has a strong focus on clinical applications in his research—providing tools and methods for athletic trainers to prevent and screen athletes for lower extremity musculoskeletal injuries and to return them to play only after any biomechanical deficits have been corrected. Padua is extremely grateful for the path (albeit unexpected) his life has taken: with enthusiasm, 100% effort, and an environment of good people, an amazing life can result.

The leadership of caring and dedicated mentors has been vital to Padua's success. He credits Robert Moore, PhD, ATC; Denise Wiksten, PhD, ATC; William Prentice, PhD, ATC, PT, FNATA; Mark Haines, MS, ATC; Kevin Guskiewicz, PhD, ATC, FNATA, FACSM; David Perrin, PhD, ATC, FNATA, FACSM; Brent Arnold, PhD, ATC; and Kevin Granata, PhD, as strong influences in his career. He appreciates his doctoral-level students for much of the "heavy lifting" in performing the research he has done and is grateful to have the opportunity to mentor many undergraduate and graduate-level students. His supportive wife, Jody Padua, and 3 daughters (Siena, Kayla, and Sophia) serve as the motivation for him to continue his work. He is also indebted to his parents, Tony and Sandee Padua, who provided him with a strong foundation and support along the way.

Although he didn't expect to pursue a career in research, Padua considers himself very lucky to have found his passion and to be able to pursue it in such a nurturing environment.

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

David R. Bell, PhD, ATC
University of Wisconsin–Madison

Growing up in a small town in rural North Carolina, David Bell didn't know what athletic training was. At the University of North Carolina at Chapel Hill, he contemplated majoring in history, biology, or chemistry before learning about athletic training, which sounded far more interesting.

Bell didn't expect to become a researcher, but seeking a challenge, he attended the University of Virginia for his master's degree. To his surprise, he found he enjoyed both research and teaching. After earning his degree, he pursued clinical experiences in outreach and high schools. However, he realized that a doctoral degree would make the best use of his skill set and so returned to the University of North Carolina at Chapel Hill to pursue his PhD.

His ability to engage deeply in a project while maintaining an open mind and remaining adaptable has contributed to his success as a researcher. Bell's research agenda focuses on injury prevention and sport specialization in young athletes, optimizing rehabilitation after surgery, and the effect of injury on physical activity. His advisor, Darin A. Padua, PhD, ATC, was instrumental in helping him to develop a progressive and focused line of research with the ultimate goal of aiding athletic trainers and their patients in the clinical setting.

Bell particularly likes teaching evidence-based practice courses. He reminds students that they collect data every day in the clinic and that in order to be good clinicians, they must be familiar with the underlying evidence, stay open to new ideas and opportunities, and expect to be lifelong learners.

Bell thanks all of his family, with special appreciation to his wife, Jennifer, and his sons, Owen and Graham. He is also grateful for his collaborators, mentors, and friends at the University of Wisconsin–Madison who have challenged his ideas and made him a better scientist. He thanks the many students who have been instrumental in the growth and success of his lab, especially Stephanie Trigsted, MS, ATC; Eric Post, MS, ATC; Dan Schaefer, MS, CSCS; Mikel Stiffler, MS; and Mason Smith, MS, ATC. He also thanks Darin Padua, PhD, ATC, and Kevin Guskiewicz, PhD, ATC, FNATA, FACSM, who have been steadfast mentors and friends. Bell is honored to receive this award in the same year that Padua is receiving the Medal for Distinguished Athletic Training Research.

NATA RESEARCH & EDUCATION FOUNDATION

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 Orthopaedic Surgery at the University of Pittsburgh School of Medicine and the UPMC Health System.

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 Health System Center for Sports Medicine—has grown into the region's largest, most comprehensive sports medicine center and is regarded as among the best in the country.

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

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

Dr. Fu is the editor of 12 major orthopaedic textbooks and author of 60 book chapters on managing sports injuries. He has contributed to more than 150 international research publications and has given more than 400 national presentations. Former President of the Pennsylvania Orthopaedic Society, he is a member of 40 other professional and academic medical organizations.

Dr. Fu has served as Chairman of the Board and Executive Medical Director of the City of Pittsburgh Marathon Inc; Company Physician and Board Member for the Pittsburgh Ballet Theatre; and Team Physician for Mt. Lebanon High School. Additionally, he is past President and Chairman of the Children's Festival Chorus and has served the Parental Stress Center, the Pittsburgh Employment Alliance, and the Organization of Chinese Americans.

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

Luke T. Donovan, PhD, ATC
University of North Carolina at Charlotte

Since he was young, Luke Donovan has always been curious about a range of topics, from why some people hold their breath longer than others to his current exploration of chronic ankle instability. Donovan learned about athletic training when he experienced an injury in his senior year of high school. He was interested in the process of injury and rehabilitation and the changes in his body throughout. While in high school, he became an Eagle Scout, a process that is similar to completing a dissertation or thesis. This endeavor provided him with the motivation and discipline to develop a large project and see it through.

When Donovan reached Pennsylvania State University (the first person in his family to attend college), he was unsure of his career path but stumbled upon athletic training and remembered his personal experience. Although his interest in chronic ankle instability began during his undergraduate education, he expected to focus on practicality (that is, being employed) after graduation rather than on his passion for inquiry. However, Program Director Lauren Kramer, PhD, ATC, had earned her master's degree at the University of Virginia (UVA) and encouraged him to apply there. When Donovan visited, he decided it was the place for him; despite concerns about never having done research on his own or having been a strong writer, he trusted his mentor.

While pursuing his master's degree, Donovan began working with Jay Hertel, PhD, ATC, FNATA, FACSM, a recognized authority on chronic ankle instability. Donovan's clinical experiences with patients who had chronic ankle instability led him to believe that this injury could be rehabilitated more effectively and that research could make that possible. He fell in love with research and therefore opted to pursue a career in higher education.

Donovan gives much of the credit for his achievements to the mentors and family who have always provided sound advice. He advises students to work hard but trust the system: subjects studied in school may not initially seem to be useful but prove important in the future. Each person has a different path to his or her end goal. He urges everyone to be a lifelong learner and always remain curious.

He thanks his parents, Dina and John, for their ongoing interest in his work and their dedication to allowing their children to pursue any career they desired. He also thanks his faculty mentors, Lauren Kramer, PhD, ATC, and John Miller, PhD, ATC, at Penn State; Jay Hertel, PhD, ATC, FNATA, FACSM; Sue Saliba, PhD, PT, ATC, FNATA, and Joseph Hart, PhD, ATC, FNATA, FACSM, at UVA; and all of his clinical preceptors at Penn State and staff athletic trainer mentors at UVA. He thanks his wife, Kristen, whom he "owes big time" for her many contributions. He is thankful to everyone who has put him on this path in life.

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

David H. Perrin, PhD, ATC, FNATA, FACSM, 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 is dean of the College of Health and professor of Exercise and Sport Science at the University of Utah.

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.

Ankle Best Practices Forum: Evaluation HRQoL Ankle

Tuesday, June 27, 2017, 8:15AM-9:15AM, Room 360; Moderator: Patrick McKeon, PhD, ATC
Discussants: Carrie Docherty, PhD, ATC; Janet Simon, PhD, ATC

Free Communications, Oral Presentations: Things That Don't Go Well Together: Ankle Sprains and Quality of Life

Tuesday, June 27, 2017, 9:30AM-10:15AM, Room 360; Moderator: Megan Houston, PhD, ATC

Influence of Self-Reported Function and Pain in Differentiating Chronic Ankle Instability and Lateral Ankle Sprain Copers

Gribble PA, Gay EM, Kosik KB, McCann RS, Terada M, Villasante AG: University of Kentucky, Lexington, KY; Ritusmeikan University, Kusatusu, Shiga-ken, Japan

Context: Previously established criteria to identify individuals with chronic ankle instability (CAI) after lateral ankle sprain (LAS) have focused on self-reported function and disability, but it is unclear whether the presence of pain during activity defines a CAI vs a LAS-Coper patient. Measures of self-reported function are primarily used to define the two groups, but certain evaluation tools, such as the Identification of Functional Ankle Instability tool (IdFAI) may contain some redundancy. It remains unknown if more streamlined patient reported outcome (PRO) models could correctly identify CAI and LAS-Copers more efficiently than the current approach. **Objective:** To evaluate a succinct approach to assessing self-reported ankle pain and function for differentiating CAI and LAS-Coper status. **Design:** Retrospective chart review. **Setting:** Research laboratory. **Patients or Other Participants:** One hundred eighty-seven volunteers that had participated in previously completed studies and were separated into CAI (n = 98; Age: 21.99 ± 3.66 yrs; Height: 169.76 ± 7.91 cm; Mass: 74.18 ± 15.64 kg) and LAS-Coper (n = 89; Age: 22.79 ± 4.44 yrs; Height: 169.40 ± 9.68 cm; Mass: 73.78 ± 15.62 kg) groups. **Interventions:** Data were extracted from participants enrolled in previous laboratory studies that compared sensorimotor characteristics between CAI and LAS-Coper groups. Classification into these groups followed the published guidelines of the International Ankle Consortium (IAC). For CAI, this included ≥1 LAS, ≥2 ankle giving way episodes in the last 6 months, and ≥11 on the IdFAI and ≤24 on the Cumberland Ankle Instability Tool (CAIT). Participants with a LAS history that did not meet those criteria were placed in the LAS-Coper group. **Main Outcome Measures:** Group status of CAI or LAS-Coper was the primary outcome measure. Patient responses to the first question of the CAIT (ankle pain during varying levels of activity; score: 0-5) and the ninth and tenth questions of the IdFAI (frequency of the ankle feeling unstable during ADL and Sport activity, respectively; scores: 0-4) were extracted from their study enrollment record. Binary logistic regression models (Cox & Snell R2) were used to predict Group status from the selected single item responses regarding self-reported instability and pain. Significance was set at $P<0.05$. **Results:** When all three items were included, a significant regression model predicted Group ($R2 = 0.63$; $P < 0.001$). When using each item individually, each produced significant prediction models [IdFAI #9 (ADL): $R2 = 0.45$, $P < 0.001$; IdFAI #10 (Sport): $R2 = 0.63$, $P < 0.001$; CAIT-Pain: $R2 = 0.20$, $P < 0.001$]. **Conclusions:** Recent guidelines for CAI criteria emphasize self-reported function. Our analysis supports IAC recommendations, but suggests potential to streamline the number of questions needed. The presence of pain during low-demand dynamic tasks may be a contributor to defining CAI, but not as definitive as self-reported function. A shorter and more streamlined PRO that includes assessment of pain with functional activities should be considered for the identification and evaluation of patients with CAI.

Test-Retest Reliability, Minimal Detectable Change and Responsiveness of the Quick-FAAM in Individuals With Chronic Ankle Instability

Hoch JM, Powden CJ, Hoch MC: Old Dominion University, Norfolk, VA

Context: The Quick-Foot and Ankle Ability Measure (Quick-FAAM) is a region-specific patient-reported outcome (PRO) developed from the original FAAM Activities of Daily Living and Sport subscales. The objective of this instrument was to reduce administration and scoring time when utilized in clinical practice. While the internal consistency and convergent and divergent validity were previously established, additional psychometric properties must be determined. **Objective:** To determine the test-retest reliability, minimal detectable change and responsiveness of the Quick-FAAM in people with chronic ankle instability (CAI). **Design:** Interrupted-time series. **Setting:** Laboratory. **Patients or Other Participants:** A total of 20 adults (15 females; age = 24.4 ± 7.0 years; height = 169.29 ± 10.1cm; weight = 70.6 ± 12.9kg) with self-reported CAI participated. Inclusion criteria were: history of ≥1 ankle sprain, ≥2 episodes of giving way in the past 3 months, answering "yes" to ≥4 questions of Ankle Instability Instrument, and scoring ≤24 on the Cumberland Ankle Instability Tool. **Interventions:** Each subject participated in a supervised 4-week intervention which included dynamic balance training, ankle strengthening exercises, and talocrural joint mobilizations over 12-sessions. Subjects also completed gastroc-soleus complex stretching and ankle strengthening exercises daily during the 4-weeks at home. The Quick-FAAM was assessed 4-weeks before the intervention (T1), prior to the first intervention (T2), 24-hours post-intervention (T3), and

2-weeks after the intervention (T4). **Main Outcome Measures:** The Quick-FAAM is a 12-item region specific PRO that assesses ankle function. The Quick-FAAM is scored on 5-point Likert scale where 0 represents no difficulty and 4 represents unable to do. The final score is often reported as a percentage, and a lower percentage indicates decreased ankle function. The dependent variables were scores on the Quick-FAAM and the independent variable was time (T1-T4). Mean (± standard deviation) for each time point was calculated. Test-retest reliability was determined using Intraclass correlation coefficients ($ICC_{2,1}$) and standard error of measure (SEM). The MDC was calculated using the equation: $SEM*1.96*\sqrt{2}$. Finally, Hedges g effect sizes and associated 95% confidence intervals (95%CI) were calculated to examine responsiveness over time. **Results:** The average Quick-FAAM scores for T1 was 75.12 (±11.64), for T2 was 79.38 (±11.33), for T3 was 91.88 (±7.64), and T4 was 93.3 (±6.32). The test-retest reliability was clinically acceptable ($ICC_{2,1}$ = 0.82) with an SEM of 4.28 points. The MDC was 12 points. The Quick-FAAM was responsive, with large effect sizes (ES = 1.27, 95% CI: 0.59-1.95) between T2-T3, and between T2-T4 (ES = 1.49, 95% CI: 0.79-2.19). **Conclusions:** The Quick-FAAM demonstrated clinically acceptable reliability and was responsive to treatment for individuals with CAI who participated in a 4-week intervention. Additionally, a change of ±12 points is needed to identify change outside of measurement error when using the Quick-FAAM in clinical practice. Future research should examine these properties in patients with acute ankle, foot or toe conditions and also determine patient acceptability.

Changes in Health-Related Quality of Life in Adolescent Athletes Following an Ankle Sprain Injury: A Report From the Athletic Training Practice-Based Research Network

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

Context: Ankle sprains frequently occur in adolescent sports. Current evidence suggests that most patients will report a complete recovery in self-report of function, and return to full participation within two weeks post-injury. However, little is known about potential changes in health-related quality of life (HRQOL) immediately following an ankle sprain injury. **Objective:** To determine changes in HRQOL, as measured by the Pediatric Quality of Life Scale (PedsQL), in adolescent athletes during the first two weeks following an ankle sprain injury. **Design:** Cohort. **Setting:** Athletic training clinics within the Athletic Training Practice-Based Research Network (AT-PBRN). **Patients or Other Participants:** Sixty-one patients (male = 35, female = 26, age = 15.5 ± 1.1 years, height = 174.5 ± 10.7 cm, weight = 71.0 ± 19.6 kg) who represented twelve different sports were diagnosed with an ankle sprain injury by an athletic trainer within the AT-PBRN. **Interventions:** The independent variable was time. Patients received usual care from an athletic trainer and completed the PedsQL during treatment sessions at post-injury Time 1 [(T1); range = 0-7 days post-intake] and Time 2 [(T2); range = 10-19 days post-intake]. The PedsQL is a valid, reliable, and responsive patient-reported outcome instrument that assesses HRQOL. The PedsQL generates a total (TOT) and four subscale [physical functioning (PF), emotional functioning (EF), social functioning (SOF), school functioning (SCF)] scores. All scores range 0-100, with higher scores indicating better HRQOL. The minimal clinically important difference (MCID) for the TOT is 4.4 points. **Main Outcome Measures:** Dependent variables were the PedsQL scores: TOT, PF, EF, SOF, SCF. Descriptive statistics (mean ± SD) were reported for each score, and a generalized mixed model (gamma with log link) was used to identify differences between T1 and T2. Alpha was $P < .05$, two-tailed. **Results:** Significant improvements were reported between time points for TOT ($p < 0.001$; T1 = 79.3 ± 13.8 [range = 48-100], T2 = 86.9 ± 12.3 [range = 50-100]), PF ($p < 0.001$; T1 = 63.9 ± 27.7 [range = 9-100], T2 = 78.2 ± 19.5 [range = 28-100]), EF ($p = 0.003$; T1 = 86.5 ± 13.9 [range = 50-100], T2 = 92.0 ± 13.1[range = 45-100]) and SCF ($p = 0.02$; T1 = 91.6 ± 12.0 [35-100], T2 = 93.6 ± 11.7 [range = 45-100]). No significant change was noted for SOF ($p = .21$; T1 = 84.4 ± 16.8 [range = 40-100], T2 = 88.9 ± 14.7 [range = 50-100]). When examining scores on an individual level, 55.7% (n = 34) of patients reported TOT changes that exceeded the MCID value between time points. Interestingly, 26.2% (n = 16) of patients reported a decrease in TOT between time points, and only 8.1% (n = 5) reported a complete recovery of HRQOL (ie, a score of 100) at T2. **Conclusions:** Adolescent patients who suffer an ankle sprain injury generally report statistically significant improvements in HRQOL during the first two weeks post-injury. However, almost half do not experience a meaningful change in HRQOL, and a substantial majority of patients continue to experience deficits in HRQOL within two weeks of an ankle sprain injury. Clinicians should consider assessing HRQOL to better inform patient care decisions, particularly since current literature suggests that most patients will return to full participation within two weeks of an ankle sprain injury.

Head/Spine Best Practices Forum: Computerized Neurocognitive Testing

Tuesday, June 27, 2017, 10:30AM-11:30AM, Room 360; Moderator: Scott Piland, PhD, ATC
Discussants: Jacob Resch, PhD, ATC; Ashley Santo, PhD, ATC

Concussion Disclosure Knowledge, Attitudes, Beliefs, and Behaviors Among First Year Service Academy Cadets: The BANK Study

Register-Mihalik JK, Cameron KL, Gildner P, Peck KY, Houston MN, Svoboda SJ, Kay MC, Kerr ZY, Guskiewicz KM, Linnan LA, Hennink-Kaminski H, Marshall SW: University of North Carolina at Chapel Hill, Chapel Hill, NC; Keller Army Hospital, West Point, NY

Context: Few studies have examined concussion disclosure among military service members. **Objective:** To examine the association between key demographic factors, concussion knowledge, concussion attitudes and beliefs, and concussion disclosure behaviors among incoming service academy cadets. **Design:** Cross-sectional survey. **Setting:** Classroom. **Patients or Other Participants:** All incoming (first-year) U.S. Military Academy cadets in the class of 2020 (n = 972; mean age = 18.4 ± 0.9 years; 83% response). **Interventions:** Participants completed a pre-validated, online, in-person questionnaire between May 2016 and September 2016 on self-reported concussion disclosure history and demographics. Also included were concussion knowledge (total number correct, max possible 39), attitude (sum of 7, Likert scale attitude answers, max possible 49), and belief scales (sum of 6, Likert scale belief answers, max possible 42). For each scale, a higher score indicates a more favorable outcome. All scales included had good to excellent internal consistency values (Cronbach's Alpha > 0.80). Concussion disclosure information included the total number of concussions an individual recalled, total number of concussions disclosed, and total number of concussions not disclosed. Explanatory variables of interest included: gender (male vs. female), NCAA student-athlete status (no vs. yes), concussion knowledge score, concussion attitudes score, and concussion beliefs score. **Main Outcome Measures:** The primary outcome was concussion disclosure prevalence (number of concussions reported as disclosed/total number of concussions recalled). Separate univariable binomial regression models were conducted to examine associations between each variable of interest and disclosure prevalence. A multivariable binomial regression model was utilized to predict disclosure prevalence with all variables in the model. An *a priori* alpha level of 0.05 was used. **Results:** In the total sample, 201 (20.6%) were female (41 not reporting gender; 6 reporting other or transgender) and 281 (28.9%) were NCAA student-athletes. Average concussion knowledge, attitudes, and beliefs scores were 32.1 (95% CI: 31.6, 32.5), 33.8 (95% CI: 33.4, 34.2), and 42.3 (95% CI: 41.9, 42.6), respectively. Overall, 206/972 (21.2%) cadets recalled at least one previous concussion and were included in the regression analyses. Of these 206, 72 (34.9%) reported at least one episode of non-disclosure. Being a non-NCAA student-athlete vs. a NCAA student-athlete was associated with a 20% lower disclosure prevalence (prevalence ratio [PR] = 0.8, 95% CI: 0.7, 0.9), while an increase of seven belief score points was associated with a 20% higher disclosure prevalence (PR = 1.2, 95% CI: 1.1, 1.3). **Conclusions:** Being a non-NCAA student-athlete vs. a NCAA student-athlete was associated with lower disclosure prevalence in both models. More favorable concussion disclosure beliefs and expectations were associated with better disclosure prevalence. When designing concussion education and intervention strategies for incoming service academy cadets, clinicians should direct targeted information towards non NCAA student-athletes. In addition, an understanding of beliefs held by incoming cadets may aid in messaging to improve concussion disclosure in this population.

The Influence of Self-Reported Tobacco Use on Baseline Concussion Assessments Among Service Academy Cadets

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Context: Baseline symptom, balance, and neurocognitive scores have become an integral piece of the concussion management process. While factors such as sleep, learning disorders, and gender have been linked to performance differences on baseline concussion assessments, it is unclear how tobacco use may affect these scores. **Objective:** To compare baseline concussion assessment scores between military cadets that use tobacco and those that do not. **Design:** Cross-sectional. **Setting:** US service academies. **Patients or Other Participants:** 7154 cadets (Tobacco: 1178 males, 54 females; 19.98 ± 1.38 y, 70.93 ± 3.16 in, 181.92 ± 28.75 lbs; Non-tobacco: 4421 males, 1501 females; 19.64 ± 1.50 y, 69.56 ± 3.68 in, 165.87 ± 27.68 lbs) were recruited from two US service academies. On average, tobacco users smoked 1.67 ± 6.49 cigars/cigarettes or used 0.92 ± 1.46 cans of dip per week. **Interventions:** Cadets completed the Balance Error Scoring System (BESS), Standardized Assessment of Concussion (SAC), Immediate Post-Concussion Assessment and Cognitive Test (ImPACT), Brief Symptom Inventory-18 (BSI-18), and Brief Sensation Seeking Scale (BSSS) as part of their annual baseline. The BSI-18 (score range = 0-72) is used to measure symptoms of distress and the BSSS (score range=1-5) is used to assess risk taking behaviors. Higher scores

indicate greater distress and individuals more likely to take risks, respectively. Additionally, cadets were asked if they had used tobacco in the past month. **Main Outcome Measures:** The independent variable was tobacco use; dependent variables included BESS, SAC, ImPACT individual composite scores (visual memory, verbal memory, visual motor speed, reaction time, impulse control, symptom severity), BSI-18, and BSSS scores. Separate Mann-Whitney U-tests were used to compare all baseline assessment scores between groups ($p < 0.05$). The z values ($r = z/\sqrt{n}$) were used to estimate effect sizes (ES). ES strengths were interpreted as small (0.01-0.39), medium (0.40-0.69), and large (0.70-1.00). Descriptive statistics were reported as median(interquartile range) and mean±standard deviation. **Results:** Group differences were detected for verbal memory (Tobacco: 92.00 (83.00-97:00), 88.98 ± 9.95; Non-tobacco: 92.00 (84.00-98.00), 89.72 ± 9.59, $p = 0.0231$, ES = 0.027), impulse control (Tobacco: 5.00 (3.00-8.00), 6.47 ± 6.19; Non-tobacco: 5.00 (3.00-8.00), 5.79 ± 5.38, $p < 0.001$, ES = 0.056), symptom severity (Tobacco: 1.00 (0.00-5.00), 3.84 ± 6.94; Non-tobacco: 0.00 (0.00-4.00), 2.89 ± (5.64), $p < 0.001$, ES = 0.061) and the BSSS (Tobacco: 3.75 (3.25-4.13), 3.69 ± 0.67; Non-tobacco: 3.38 (3.00-3.88), 3.37 ± 0.68, $p < 0.001$, ES = 0.184). No differences were detected for BESS (Tobacco: 12.00 (9.00-17.00), 13.42 ± 6.47; Non-tobacco: 12.00 (9.00-17.00), 13.44 ± 6.28), SAC (Tobacco: 28.00 (27.00-29.00), 27.68 ± 1.80; Non-tobacco: 28.00 (27.00-29.00), 27.65 ± 1.88), visual memory (Tobacco: 84.00 (75.00-92.00), 81.76 ± 12.57; Non-tobacco: 83.00 (74.00-91.00), 81.73 ± 12.15), visual motor speed (Tobacco: 43.45 (38.70-47.70), 42.90 ± 6.02); Non-tobacco: 43.63 (38.85-47.75), 43.02 ± 6.07), reaction time (Tobacco: 0.56 (0.52-0.61), 0.59 ± 0.37; Non-tobacco: 0.56 (0.52-0.61), 0.58 ± 0.14), or the BSI-18 (Tobacco: 0.00 (0.00-2.00), 2.01 ± 3.56; Non-tobacco: 0.00 (0.00-2.00), 2.37 ± 4.99) ($p > 0.05$). **Conclusions:** Tobacco users performed significantly worse than non-tobacco users on the verbal memory and impulse control sections of the ImPACT, reported greater symptom severity scores on the ImPACT, and were more likely to take risks as measured by the BSSS. However, these results should be interpreted with caution, as the effect sizes were small. Future research should examine the influence of tobacco use on recovery post-concussion.

Reference Values for the Balance Error Scoring System in Military Cadets

Houston MN, Peck KY, Malvasi SR, Roach SP, Carminati SK, Svoboda SJ, Cameron KL: Keller Army Community Hospital, West Point, NY

Context: The Balance Error Scoring System (BESS) is commonly used to measure postural stability; however it has demonstrated poor reliability when administered by humans. The Tekscan MobileMat was developed to automate BESS errors and eliminate rater subjectivity. To date, normative values have been reported for the human-rated BESS, but not for the MobileMat. Additionally, the influence of gender, concussion history, and level of competitive sport on BESS performance is unclear. **Objective:** To report reference values for the BESS, as measured by the MobileMat, in military cadets and examine the effect of gender, concussion history, and competitive sport level on BESS performance. **Design:** Cross-sectional. **Setting:** US Service Academy. **Patients or Other Participants:** 345 male (20.31 ± 1.34 y, 70.34 ± 3.02 in, 174.06 ± 21.07 lbs) and 95 female (19.78 ± 1.09 y, 65.15 ± 2.83 in, 141.80 ± 16.60 lbs) cadets were recruited from a US service academy. Cadets participated in NCAA (n = 93), club (n = 80), and intramural athletics (n = 267) and 92 (15 female) reported a history of concussion. **Interventions:** The BESS was performed using a MobileMat as part of an annual battery of baseline concussion assessments. Cadets performed three stances (double limb (DL), single limb (SL), tandem) under two conditions (firm, foam) for a total of six stances. The cadets were asked to maintain each stance with their eyes closed for 20 seconds. The MobileMat was used to quantify the number of BESS errors. BESS scores range from 0-10 for each stance with lower values representing better postural stability. **Main Outcome Measures:** Reference values [mean ± standard

deviation; median(interquartile range)] are stratified by sex for each BESS stance. Mann-Whitney U and Kruskal-Wallis tests were used to examine the effect of sex, concussion history, and competitive sport level on BESS performance. Alpha was set a-priori at $p < 0.05$. In the event of a significant Kruskal-Wallis test, separate Mann-Whitney U-tests were performed to determine where differences occurred with an adjusted p-value ($p < 0.017$). **Results:** Reference values for BESS firm stances were: DL [Male: 0.01 ± 0.22; 0.00 (0.00-0.00); Female: 0.01 ± 0.10; 0.00 (0.00-0.00)], SL [Male: 4.09 ± 2.51; 4.00 (2.00-6.00); Female: 4.29 ± 2.55; 4.00 (3.00-6.00)], tandem [Male: 2.68 ± 2.15; 2.00 (1.00-4.00); Female: 2.82 ± 2.18; 3.00 (1.00-4.00)]. Reference values for BESS foam stances were: DL [Male: 0.94 ± 1.41; 0.00 (0.00-1.00); Female: 1.19 ± 1.59; 1.00 (0.00-2.00)], SL [Male: 6.82 ± 2.31; 7.00 (5.00-9.00); Female: (7.40 ± 2.26; 8.00 (6.00-10.00)], tandem [Male: 5.25 ± 2.51; 5.00 (3.00-7.00); Female: 5.35 ± 2.37; 5.00 (3.00-7.00)]. Males performed significantly better than females for the SL foam stance ($p = 0.032$). No sex differences were detected for the other five BESS stances ($p > 0.122$). Concussion history and competitive sport level did not affect BESS performance ($p > 0.279$). **Conclusions:** Previously reported reference values in collegiate athletes and adolescents were slightly higher thus highlighting the value in establishing population norms and in developing new technologies to objectively quantify BESS performance. Furthermore, based on our findings, sex, concussion history, and competitive sport level do not appear to play a role in BESS performance as measured by the MobileMat.

Factors Associated With Delayed Concussion Reporting in Military Academy Cadets

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Context: Approximately half of individuals who sustain a concussion do not immediately report their injury. Motivators for not reporting a concussion include thinking the suspected concussion was not a serious injury and wanting to continue participating in their activity. Additionally, military personnel often have concerns about how their injury may affect their careers. However, delayed reporting can prolong neurobehavioral recovery or result in more serious injury. Understanding the frequency of delayed reporting and factors that may contribute will aid in identifying individuals that may be at risk for prolonged recovery. **Objective:** To describe the frequency of delayed concussion reporting in military cadets and to determine if sex, concussion history, or competitive sport level are capable of predicting delayed reporting. **Design:** Prospective cohort. **Setting:** United States Service Academies. **Patients or Other Participants:** 316 concussions were observed in cadets enrolled in the Concussion Assessment, Research and Education Consortium at two service academies from May 2015 to August 2016. In this cohort, 117 cadets (44 females) had a prior history of concussion and 116 (35 females) of the concussions were sustained by National Collegiate Athletic Association (NCAA) cadet-athletes. **Interventions:** All cadets completed an annual concussion baseline that included symptom, postural stability, and neurocognitive assessments. Other information collected included demographics, medical history, and sports participation information. Post-concussion, the treating clinician documented if the cadet immediately reported the injury. **Main Outcome Measures:** Delayed report (yes, no) served as the outcome variable. Predictor variables included sex (male, female), concussion history (yes, no), and competitive sport level (NCAA, non-NCAA). Percentages were used to describe the frequency of delayed reporting in cadets. A binary logistic regression model ($p<0.05$) was used to assess if sex, concussion history, or competitive sport level predicted delayed report in concussed cadets. Odds ratios (OR) and 95% confidence intervals (95%CI) are reported for significant predictors. **Results:** 50.3% of cadets (95 males, 64 females; 19.03 ± 1.40 y, 69.36 ± 4.02 in, 164.31 ± 28.54 lbs) continued to participate in activity beyond their concussive event or neglected to report the event and were thus classified as a delayed report. 49.7% of cadets (111 males, 46 females; 19.00 ± 1.34 y, 68.91 ± 4.20 in, 168.30 ± 37.62lbs) immediately reported the concussive event to a member of the medical staff. The overall regression model ($x^2 = 12.72$, $p = 0.005$) explained 5.70% of the variance and correctly classified 59.90% of all cases. Females (OR = 1.829, 95% CI: 1.11, 3.01) and NCAA cadet-athletes (OR = 1.85, 95% CI: 1.12, 3.02) were more likely than their peers to delay reporting. **Conclusions:** Our data suggests that roughly half of cadets that sustain a concussion fail to immediately report their injury. Sex and competitive sport level appear to elevate the odds of a cadet delaying to report a concussion. Specifically, our data suggests that females and NCAA cadet-athletes are almost twice as likely to delay reporting.

Free Communications, Oral Presentations: Considerations for Secondary School Athletic Trainers

Wednesday, June 28, 2017, 7:15AM-8:00AM, Room 360; Moderator: Kelly Pagnotta, PhD, ATC

Employment of Athletic Trainers in Secondary Schools: The ATLAS Project

Attanasio SA, Huggins RA, Cooper GL, Harper RC, Scarneo SE, Pike AM, Rourke JE, Morris RF, Huemme KL, Bruneau KJ, Casa DJ: Korey Stringer Institute, Department of Kinesiology, University of Connecticut, Storrs, CT; Penn Trafford High School, Harrison City, PA; Dutchtown High School, Geismar, LA

Context: Previous research of secondary school administrators has determined that 70% of public and 58% of private schools nationwide have access to an athletic trainer. Additionally, 37% of public and 28% of private school administrators reported having full time AT services. However specific information reported from athletic trainers regarding their specific employer has not been documented. **Objective:** To quantify current employment providers of AT services in the secondary school setting nationwide. **Design:** Longitudinal, survey-based questionnaire. **Setting:** Public, private, charter, magnet, special education and alternative secondary schools in the United States. **Patients or Other Participants:** Secondary school certified athletic trainers. **Interventions:** Secondary school ATs completed an online questionnaire from June 2015 to November 2016. **Main Outcome Measures:** Data for full-time (FT) and part-time (PT) AT services and primary employer were obtained. Full-time services were defined as all of the following: AT services provided to only 1 school, ³5 days per week, ³30 hours per week, and ³10 months per year. Part-time services were defined as anything less than FT. Athletic trainer employment status was collected and split into four categories: school district employees (SDE), school district employees with teaching responsibilities (SDET), medical or university facility employees (MUE), or independent contractors (IC). Data are presented as total number and percent (%) of athletic trainers. **Results:** Athletic trainers (n = 3836) from 50 states and one province responded to the survey. Eighty-one percent (n = 3136/3836) worked in public schools, 16.69% (n = 627/3836) in private schools, and 1.9% (n = 73/3836) in charter, magnet, special education and alternative schools combined. Overall, 27% (n = 1052/3836) of athletic trainers are SDE, 16% (n = 630/3896) are SDET, 51% (n = 1965/3836) are MUE, and 5% (n = 189/3836) are IC. Total number of athletic trainers employed by the school district (SDE + SDET) was 43% while a majority of athletic trainers were not employed by the school district (MUE + IC) was 57%. Seventy-six percent (n = 2918/3836) of athletic trainers reported working FT. Of the FT athletic trainers, 31% (n = 908/2918) were SDE, 18% (n = 515/2918) were SDET, 48% (n = 1389/2918) were MUE, and 3% (n = 97/2918) were IC. Of the remaining 24% working PT, 16% (n = 144/917) were SDE, 12% (n = 115/917) were SDET, 62% (n = 576/917) were MUE, and 10% (n = 92/917) were IC. **Conclusions:** Athletic trainers employed by a medical or university facility to provide AT services to the secondary school was the most common, followed by employment through the school district without teaching, school district with teaching responsibility, and independent. Nationally, it is more common for an AT to be hired from an outside source (MUE + IC) than by the school district (SDE + SDET). These data will enhance knowledge of and identify current employment methods for school districts/organizations looking to higher an AT in the high school setting.

Secondary School Athletic Trainers' Perceptions, Practices, and Barriers to the Use of Patient Rated-Outcomes Measures

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Context: Incorporating patient reported outcomes (PROs) into daily routine is essential for patient-centered clinical practice. Secondary school athletic trainers (ATs) may experience unique barriers that limit their willingness to use PROs in their setting. **Objective:** To explore how secondary school ATs using PROs perceive the uses, benefits, and problems of these measures compared to those who do not. **Design:** Cross-sectional study **Setting:** Cross-sectional study **Patients or Other Participants:** 2984 secondary school ATs received an email invitation with 322 completing the survey (response rate = 10.8%). Respondents were 43 ± 10 years old, 48% female (n = 154), with most indicating at least 11 years as a BOC certified athletic trainer (n = 276, 85.7%) **Interventions:** Secondary school ATs were invited to complete a web-based survey regarding knowledge, benefits, uses, and problems of using PROs. ATs currently using PROs in clinical practice were asked to indicate the criteria used to select the measures while those not using PROs were asked to indicate the reasons for not using the tools. The survey was modified from a previously validated instrument and content analysis was solicited from an expert panel of clinicians and researchers with experience using and evaluating PROs. Questions presented participants with a statement about PROs and asked them to rate their level of agreement with the statement using a five point Likert-style scale (5 = strongly agree, 4 = agree, 3 =

neither agree or disagree, 2 = disagree, 1 = strongly disagree) **Main Outcome Measures:** Dependent variables were endorsements of benefits, uses, and problems of PROs. Statements about PROs were considered endorsed with responses of Agree or Strongly Agree. We calculated statistics of central tendency (means, standard deviations, and frequencies) for all measures. **Results:** Improving communication with the patient (267/296, 90%) and helping direct the plan of care (256/297, 86%) were the most frequently endorsed benefits of PROs. The most frequently endorsed uses of PROs were determining treatment effectiveness (193/264, 73%) and demonstrating effectiveness to administration (174/264, 66%). Time to score and analyze (152/284, 53%) and time for patients to complete (134/284, 47%) were the most frequently endorsed problems of PROs. For ATs not using PROs (223/262, 85%), the most frequent reasons were requiring a support structure that they do not have (102/219, 46%), and too much time to score (90/219, 41%). For ATs using PROs (39/262, 15%), quick completion times (32/39, 82%) and easy to understand (31/39, 79%) were the most frequent criteria used to select measures for clinical use. **Conclusions:** Although secondary school ATs recognize the uses and benefits of using PROs, a majority still do not use them in clinical practice. For the athletic training profession to become more evidence-based and patient-centered, it is important to understand and address the perceived barriers to PRO use in the second largest practice setting.

Implementation of Emergency Action Plan Policies in Secondary School Athletics

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Context: In order to appropriately and adequately respond to emergency situations, such as natural disasters or serious illnesses and injuries, during sanctioned athletic events, it is compulsory that an emergency action plan (EAP) be in place. An EAP should be developed with site-specific instructions, coordinated with local emergency medical services, distributed and rehearsed with all staff members, and should include important phone numbers and information to be followed post-emergency situation. However, the extent that these EAP recommendations are implemented at the secondary school level is unknown. **Objective:** Describe the extent of state high school athletics associations (SHSAAs) that require respective member secondary schools to develop and implement an EAP that meets 11 current evidence-based minimum best practice recommendations. Additional consideration was given if guidelines had improved from the previous year (2014-2015). **Design:** Descriptive study. **Setting:** Secondary school athletics. **Patients or Other Participants:** SHSAA policies and procedures, in addition to state legislation, for handling sport related emergencies. **Data Collection and Analysis:** Eleven recommendations for meeting minimum best practices for EAPs were derived from the "The Inter-Association Task Force for Preventing Sudden Death in Secondary School Athletics Programs: Best-Practice Recommendations". An extensive review of SHSAA handbooks, constitutions, bylaws, policies and procedures, SHSAA websites, and enacted state legislation was performed for the academic year 2015-2016 to identify the inclusion of the aforementioned recommendations into mandated and required policies for the member schools governed by the SHSAA. Frequencies were tabulated for each recommendation separately, as well as for an EAP in its entirety and presented as a representative sample of the United States and District of Columbia. Percent improvement from the 2014-2015 academic year by individual recommendation was also calculated. **Results:** Currently, 36/51 (71%) SHSAA do not have requirements for implementing EAPs in sanctioned athletics. West Virginia meets the greatest number of recommendations (8/11; 72%) for EAP minimum best practices. Of the 11 policy components, the recommendation: "every school or organization that sponsors athletics should develop an EAP for managing serious and/or potentially life-threatening injuries" has the highest compliance (14/51 states, 28%). The recommendations: "Policy should specify documentation actions that need to be taken post emergency" and "Facility address, location, contact information, etc. should be identified in the EAP" had the least compliance with adoption in less than 4% of all states. Seven states (14%) fulfill the recommendation that the EAP is specific to each venue and includes maps and/or specific directions to that venue; a 4% improvement from the 2014-2015 school year. **Conclusions:** Despite these recommendations, very few states implement potentially life saving evidence-based guidelines for an EAP in athletic settings. More importantly, fewer demonstrate advancement to adopt these recommendations. Future advocacy and education is needed to increase compliance with the present criteria.

Shoulder Best Practices Forum: Criteria-Based Return to Sport in the Throwing Athlete

Wednesday, June 28, 2017, 8:15AM-9:15AM, Room 360; Moderator: Charles Thigpen, PhD, PT, ATC, ATI; Discussants: Sue Falsone, PT, ATC, SCS; Ellen Shanley, PhD, PT, OCS

Relationship Between Throwing Velocity and Physical Characteristics in Adolescent Baseball Players

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Context: Many adolescent baseball players have extended seasons and training periods potentially contributing to overuse injuries. Shoulder and elbow overuse injuries are most common in baseball pitchers. Previous research has identified physical characteristics that may predispose adolescent baseball pitchers to these injuries. To date, there is limited research evaluating how the physical characteristics that may influence injury risk affect pitching velocity in adolescent baseball pitchers. **Objective:** To evaluate the relationship between glenohumeral rotational range of motion, muscle strength, humeral retrotorsion and throwing velocity. **Design:** Correlational Research Design. **Setting:** Field Laboratory. **Patients or Other Participants:** 57 youth baseball players were recruited from a baseball training facility for participation (age = 13.1 ± 2.7 years; height = 163.1 ± 16.8 cm; mass = 57.1 ± 19.7 kgs). **Interventions:** Participant demographics were collected and then a standardized warm-up including both dynamic stretching and throwing was completed. Following the warm up, pitching velocity, dominant internal rotation (IR) and external rotation (ER) range of motion (ROM), humeral retrotorsion, and dominant glenohumeral IR, ER, abduction and scapular retraction muscle strength were assessed. **Main Outcome Measures:** A three-trial mean was calculated for ROM, humeral retrotorsion, strength and pitching velocity assessments. All strength values were normalized to the participant's body weight. A Pearson correlation coefficient was calculated to evaluate the relationship between pitching velocity and dominant IR and ER ROM, humeral retrotorsion, and dominant normalized glenohumeral IR, ER, abduction and scapular retraction muscle strength. **Results:** Strong correlations were present between throwing velocity and normalized IR strength ($r = 0.770$, $p < 0.005$), normalized ER strength ($r = 0.833$, $p < 0.005$), and normalized retraction strength ($r = 0.682$, $p < 0.005$). There was a weak correlation between throwing velocity and ER ROM ($r = 0.310$, $p = 0.017$) and throwing velocity and humeral retrotorsion ($r = 0.310$, $p = 0.017$). There were no significant correlations between throwing velocity and IR ROM ($r = 0.038$, $p = 0.777$) or abduction muscle strength ($r = 0.010$, $p = 0.943$). **Conclusions:** Glenohumeral IR and ER strength and scapular retraction strength correlate the strongest with throwing velocity in adolescent youth pitchers. These findings suggest that strengthening of the muscles that produce these movements may also increase throwing velocity. Further, previous literature has suggested that strengthening of these muscles may decrease the risk of shoulder and elbow injury; thus strengthening of muscles that contribute to glenohumeral IR and ER as well as scapular retraction may potentially contribute to improvement in performance while decreasing injury risk. Research is needed to evaluate the effectiveness of programs for improving strength with the ultimate goal of performance improvement and injury prevention. Additional research is also needed to understand how changes in strength and humeral retrotorsion over time influence performance and injury risk in baseball pitchers.

Associations of Baseball Pitching Technical Errors at Stride Foot Contact, Maximal External Rotation, and Ball Release

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Context: Poor pitching biomechanics are hypothesized to contribute to pain and injury in the upper extremity of the throwing athlete, but advanced biomechanical assessments are not feasible in the clinical setting. Easily identifiable pitching technical errors, developed for clinical settings to visually identify faulty mechanics, are associated with potentially harmful pitching kinetics and kinematics that may increase injury risk. Pitching technical errors are evaluated at critical instances in the pitching motion, such as stride foot contact (SFC), maximum external rotation (MER), or ball release (BR). Associations between errors at SFC and errors at MER or BR could allow clinicians to intervene at SFC to correct the errors. Intervention at SFC may be more practical than addressing each specific error, as the overall speed of the pitching motion is slower at this time. **Objective:** To determine the association of pitching technical errors at SFC and pitching technical errors at MER and BR in adolescent baseball pitchers. **Design:** Cross-sectional **Setting:** Outdoor and indoor pitching mound. **Patients or Other Participants:** 77 adolescent baseball pitchers (age: 14.23 ± 1.34 years, height: 170.34 ± 11.37 cm, weight: 62.1 ± 13.48 kg, fastball velocity: 29.9 ± 3.52 m/s) **Interventions:** Participants pitched 15 fastballs from an age prescribed distance while a high

speed camera (300 fps) recorded in the frontal and sagittal planes. Velocity and ball/strikes were recorded. The 3 fastest strikes were graded for the 5 pitching technical errors. **Main Outcome Measures:** Three errors occur in the frontal view: 1) open shoulder at SFC (OS) 2) backwards lean at SFC (BLSFC), 3) lateral lean at MER (LLMER). Two errors occur in the sagittal view: 1) lateral lean at SFC (LLSFC) and 2) forward trunk tilt less than 20 degrees at BR (FT). A Pearson chi-square test of association was performed between the presence of errors at SFC (OS, BLSFC, LLSFC), and the presence of errors at MER and BR (LLMER, FT). Fisher's Exact tests were used if expected counts were not over 5 in all cells. All analyses were performed with the alpha level set at $\alpha = 0.05$. **Results:** BLSFC significantly associates with LLMER ($\chi^2 = 32.782$, $p < 0.001$), indicating those with BLSFC also demonstrate LLMER. LLSFC significantly associates with FT (Fisher's Exact test: $p = 0.005$) indicating those with LLSFC also demonstrate FT. There were no associations between OS and LLMER and FT. **Conclusions:** Participants with pitching errors at SFC are also likely to have errors later in the pitching motion. Previous work has shown that the errors at MER and BR can increase joint load, leading to an increase in injury risk. Clinicians may be able to intervene at SFC to correct subsequent errors later in the pitching motion that may affect the pitching related pain and injury.

Analysis of Trunk Movement During Pitching Using Inertial Measurement Unit

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Context: Pitching technique is one of many factors that affect risk of shoulder and elbow injuries among pitchers. Since trunk movement patterns during pitching have been linked to increase joint loading and performance, development of an easy, reliable, and valid method to conduct movement analysis on the field would be useful. Inertial measurement unit (IMU) is a wearable device that integrates inputs from the accelerometer, gyroscope, and magnetometer. The portability of the system allows the sensor to be used outside of the laboratory in a real-life environment. **Objective:** To investigate the feasibility of analyzing trunk movement during pitching using a wearable IMU system by assessing its reliability and validity. **Design:** Cross-sectional study. **Setting:** Biomechanics research laboratory. **Patients or Other Participants:** Ten baseball pitchers (age = 18.3.0 ± 3.8 years, height = 1.8 ± 0.1 m, mass = 75.5 ± 16.3 kg, years of experience = 6.9 ± 4.6years, right/left dominance = 9/1) participated. **Interventions:** The pitchers' throwing mechanics were captured using IMU sensors and optical motion analysis system simultaneously. The participants performed fifteen pitches, and the three fastest pitches were used for analysis. **Main Outcome Measures:** The instant of maximum arm-cocking (external rotation) was identified using the angular velocity (gyroscope) data of the IMU sensor on the wrist. The data 1-second before and 0.5-second after the maximum arm-cocking were used to calculate maximum trunk flexion and lateral flexion angles using a complementary weighting algorithm-based estimate, and peak trunk and pelvis rotation velocity from the gyroscope data. The time between two velocity peaks was also calculated. Corresponding variables were calculated using the marker coordinate data. The between-pitch reliability of the IMU variables and agreement of the variables with the data collected from the optical motion capture system were evaluated using intra-class correlation coefficients (ICC). **Results:** : The variables calculated using the IMU sensors were highly reliable ($ICC_{2,k}$ = .903-.966), except for the time duration between the peak trunk and pelvis rotation velocities. The agreement for peak trunk and pelvis axial rotation velocity were moderate ($ICC_{2,k}$ = .400-.603), while the agreements for peak trunk flexion and lateral flexion angles were low (.036-.144). **Conclusions:** The variables calculated using the IMU sensors were very repeatable, which suggests that it may be used to detect changes in movement patterns within a pitcher. Trunk and pelvis angular velocity cannot be measured on-the-field using video cameras, and thus use of IMU may be utilized in training and rehabilitation. Further investigation on the filtering parameters, computation algorithms, along with improvements in sensor/strap design to minimize accessory sensor movement may improve utility of the IMU system in analysis of pitching motion and beyond.

Responsiveness of the Functional Arm Scale for Throwers© (FAST) in Injured Baseball Players

Bay RC, Huxel Bliven KC, Snyder Valier AR, Sauers EL:
A.T. Still University, Mesa, AZ

Context: The Functional Arm Scale for Throwers© (FAST) is a 22-item upper extremity (UE) region-specific and population-specific patient-reported outcome (PRO) scale developed to measure health-related quality of life (HRQOL) in throwers with UE injuries. The FAST has been shown to be reliable and valid; however, its responsiveness has not been demonstrated. **Objective:** To determine if the FAST is responsive to patient change over time. **Design:** Cohort. **Setting:** Athletic training clinics in secondary school and college settings. **Patients or Other Participants:** Eighteen baseball players with UE injuries (age, 20 ± 2.2 years) provided data for the responsiveness analysis. They reported a variety of UE injuries, from soft tissue contusions to a SLAP lesion. **Interventions:** The independent variable was time. Patients received usual care from certified athletic trainers and completed the FAST at intake and at discharge. At discharge, patients also completed a single-item global rating of change (GROC) to indicate their perceived level of change in health status between intake and discharge. **Main Outcome Measures:** Responsiveness of the FAST was evaluated using a test of difference in the score between intake and discharge (Wilcoxon), the standardized response mean, effect size, correlation of the FAST change score with the GROC, and the arear under the receiver operating characteristic curve (AUC) to discriminate between patients who had improved and those who had not improved. GROC was measured using a 7-point Likert-type scale, ranging from "a great deal worse" (1) to "a great deal better" (7). Patients were classified as improved if they endorsed "somewhat better," (6) or higher and not improved if they endorsed a lower rating at discharge. Higher scores on the FAST (which ranges 0-100) indicate worse HRQOL. **Results:** Treatment intervals (intake to discharge) ranged from 12-to-96 days [median = 27.5, interquartile range (IQR) = 19.3, 55.5]. At intake, the median (IQR) FAST total score was 43.8 (22.5, 52.0), and at discharge, 16.2 (8.2, 29.0). The median (IQR) change in the FAST during treatment was -21.0 (-34.1, -4.3), $Z = 2.7$, $p = .007$. The standardized response mean for the change score was -0.79; the effect size, -0.99. The correlation between the FAST change score and the GROC was strong, $r = -.68$, $p < .01$. The AUC for discrimination between improved and not improved patients was outstanding, at .946. **Conclusions:** The FAST is responsive and able to capture changes in patient health status over time. The change in the FAST total score was strongly correlated with the patient's perception of improvement and it shows outstanding ability to discriminate between subjects who had improved and those who had not improved. The large effect size and standardized responses means found for the FAST also demonstrate its responsiveness, which matches or exceeds other commonly used UE PROs.

Free Communications, Oral Presentations: Learning Practices in Athletic Training Education

Wednesday, June 28, 2017, 5:00PM-6:15PM, Room 360; Moderator: Stacy E. Walker, PhD, ATC, FNATA

Simulated Patients Are Predominately Used to Teach and Evaluate Athletic Training Student's Skills: A Ten-Year Follow- Up Study

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Context: Researchers previously established that simulated patients were the predominate method used to evaluate athletic training student's performance on clinical [integration] proficiencies during clinical education. However, the researchers did not examine the methods used to teach and evaluate these skills in the classroom/laboratory. **Objective:** To follow-up on the methods athletic training educators use to teach and evaluate athletic training student's clinical skills during clinical education and also in the classroom/laboratory. **Design:** Cross-sectional. **Setting:** Public and private institutions. **Patients or Other Participants:** Program directors of all accredited professional athletic training programs as of November 2015, excluding the host institutions (n = 385) were emailed the "Methods Used to Teach and Evaluate Athletic Training Students" survey. A total of 93 program directors (24.2%) participated. **Interventions:** Data from two focus groups guided the revision of the original instrument. The follow-up survey was administered electronically. Cronbach's alpha determined internal consistency, with an alpha coefficient of .784. **Main Outcome Measures:** The survey consisted of 6 institutional/program demographic questions (e.g., level of degree offered, number of students in program); 6 questions regarding methods used to teach and evaluate athletic training skills (e.g., real-time patients, simulated patients) during the classroom/laboratory and clinical education; and 6 Likert scale (1 = strongly disagree - 5 = strongly agree) items regarding barriers, educational content areas, and clinical education settings for teaching and evaluating skills. Descriptive statistics were computed for all items. An analysis of variance (ANOVA) and independent t-tests analyzed differences between demographic characteristics of the institution/programs and the methods, barriers, educational content areas, and settings regarding the teaching and evaluating skills. The alpha level was set at.05. **Results:** Simulated patients (n = 85, 94.4%; n = 54, 60.7%) and real-time (n= 50, 56.8%; n = 54, 60.7%) evaluations were the most prevalent methods of teaching and evaluating clinical skills in the classroom/laboratory and during clinical education, respectively. Nearly half (n = 44, 48.9%) of participants reported that students completed more than 10 real-time patient encounters during clinical education per semester. A lack of students' self-confidence (4.10 + *0.835*) was the most common barrier to real-time evaluation during clinical education. The clinical examination and diagnosis (4.54 + *0.656*) and acute care of injury and illness (4.39 + *0.775*) ranked highest relative to sufficient opportunities existing in each for real-time skill evaluation. One-way ANOVAs revealed no significant differences between institutional/program demographics and opportunities and barriers regarding teaching and evaluating skills across clinical education settings. **Conclusions:** 10 years later, athletic training students' skills are being taught and evaluated via simulated patients with an increase in real-time patient encounters. Professional programs are encouraged to continue utilizing simulations and consider real-time encounters to provide additional patient care experiences in the classroom/laboratory.

Student Perceptions of Standardized Patient Use in Athletic Training Education

Gardiner AM, Cuchna JW, Walker SE, Clines SH, Welch Bacon CE, Van Lunen BL: Old Dominion University, Norfolk, VA; Ball State University, Muncie, IN; A.T. Still University, Mesa, AZ

Context: Though commonplace in medical education, only recently have standardized patients (SPs) been introduced into athletic training (AT) curricula. Limited research exists on student perceptions of SPs as an evaluative and learning tool. **Objective:** To explore AT students' perceptions of SP experiences. **Design:** Qualitative. **Setting:** Individual phone interviews. **Patients or Other Participants:** Nine athletic training students in the final semester of their program (7 professional baccalaureate, 2 professional post-baccalaureate; 8 females, 1 male; 23.89 + 3.33 years of age) participated. Participants were recruited based off of a previous study which identified faculty who utilize SPs within their program. Data saturation guided the total number of participants. **Data Collection and Analysis:** Interviews occurred using a semi-structured interview guide, were audio recorded, and transcribed verbatim. Data were analyzed using a consensual qualitative research approach. Trustworthiness of the data was established through the use of a five person research team including both internal and external auditors for multiple-analyst triangulation as well as member checking. **Results:** Participants experienced a range of 4-12 overall SP encounters. The frequency of the encounters in one semester ranged from 1-8 encounters. SPs were utilized for evaluation (n = 6), teaching (n = 3), and interprofessional collaboration (n = 2). Participants interacted with SPs in groups (n = 6) and individually (n = 5). All participants received some form

of feedback (e.g. from faculty, SPs, peers, or self-reflection) following their encounters (n = 9). Two overarching themes were identified regarding the perceptions of the SP experiences: 1) encounter characteristics and 2) perceived value. Participants described typical SP encounter characteristics, including the environment where they occurred, and the format and content of the encounter. SPs were primarily utilized to provide exposure to orthopedic evaluation, general medical illnesses and conditions, and emergency situations. Students felt SPs were valuable for improving both clinical skills (e.g. history taking, vital signs, comprehensive evaluation) and professional skills (e.g. communication, confidence, clinical decision making). Most participants felt the encounters were authentic and that they were able to transfer skills learned into their clinical practice. Students expressed a desire to have more SP encounters throughout their curriculum to increase preparedness for clinical practice. The challenges associated with SP experiences included difficulty interacting with peers in group encounters and limitations in the accuracy of the portrayals. Overall, participants perceived the encounters to be positive and worthwhile experiences. **Conclusions:** Programs which utilize SPs should incorporate individual as well as group SP encounters. Group SP encounters provide the experience of approaching patient care as a team. Programs should also ensure that the experiences are authentic, applicable, and emphasize the development of professional skills, such as communication, during the experiences. Based on the demonstrated benefits of SP encounters for students, AT faculty should consider exploring ways to incorporate SPs into their curricula.

Examining the EBP Process in Cinical Education: What Drives EBP and How Are the Prongs of EBP Utilized?

Dodge TM, Guyer MS, Cook SM: Springfield College, Springfield, MA

Context: Evidence-based practice (EBP) has become a focus of the athletic training profession. Athletic training (AT) programs are required to instruct students in evidence-based techniques, and the steps associated with utilizing evidence when making clinical decisions. Research indicates that EBP concepts are being reinforced during clinical education. The question remains, however, as to what drives AT students to engage in EBP and the degree to which each of the three EBP prongs are used to enhance outcomes. **Objective:** To examine what drives AT students to engage in the EBP process and how the individual prongs of EBP influence clinical care. **Design:** Grounded theory **Setting:** A Commission on Accreditation in Athletic Training Education (CAATE) accredited undergraduate athletic training program. **Patients or Other Participants:** Ten senior-level AT students **Data Collection and Analysis:** Using semi-structured interviews, participants were asked to describe an experience where EBP was utilized. Participants identified what drove the decision to engage in the EBP process and which of the three EBP prongs most influenced clinical decision-making. Data were analyzed via a general inductive approach in order to uncover the most dominant themes. Data analysis took place in three distinctive steps including examining transcripts to gain a sense of the data, breaking down data into discrete parts, and identifying major categories. To ensure trustworthiness of the data, the researchers negotiated over the coding scheme until we came to agreement, completed peer review, and performed stakeholder checks. **Results:** Students mostly researched topics in an exploratory manner in order to learn about a particular pathology. Others performed research in order to confirm treatment decisions driven by clinical experience and patient preference. Lastly, some students were able modify existing treatment protocols by finding additional information and adapting it to the case. The clinical experience of the student and preceptor primarily influenced clinical care with patient preference often coming second and research third. Students and preceptors often treated patients for multiple weeks prior to engaging in literature searching with the intention of informing clinical care. **Conclusions:** The athletic training students in this study were able to utilize EBP in order to positively influence patient care. While EBP is often taught as a rigid process, it appears that in practice EBP is actually a fluid process that can be adapted to individual patient cases. The nature of the case will often dictate how the three prongs of EBP will be utilized to provide optimal care. Students would often wait until patient progress stagnated prior to seeking out evidence, which highlights the need to encourage students to engage in the EBP process frequently and early in the healing process. Athletic training educators should encourage students to view EBP as a dynamic process that begins immediately following injury.

Network Analysis of Clinical Placement of Athletic Training Students

Miller MG, Harvatt C, Hirsch K, Holcomb WR: Western Michigan University, Kalamazoo, MI; University of Southern Mississippi, Hattiesburg, MS

Context: Social network analysis (SNA) focuses on the relationships and connections among different people and can then be used to map out communication patterns among the different people. Strong communication in athletic training is crucial, especially in the education of young athletic trainers; therefore SNA would be a useful tool in uncovering communication patterns in undergraduate athletic training programs. **Objective:** The purposes were to determine communication aspects using SNA for on-campus and off campus clinical placement sites (CPS) of undergraduate athletic training students. **Design:** Cross-sectional research design. **Setting:** Clincal placement sites of a CAATE undergraduate professional program. **Patients or Other Participants:** The survey was sent to the preceptor, a member of the coaching staff, athletic director and hospital outreach director for both on and off campus placement sites and sent to the clinical education coordinator (CEC), program director (PD), and team physician of a Division I CAATE accredited professional program. Six males and five females (age 39.3 ± 11.1 yrs, BOC 16.9 ± 12.6 yrs) who were employed at their respective site (10 ± 8.9 yrs) participated. **Interventions:** A (10 question survey), comprised of 4 demographic questions and 6 clinical placement questions investigating decision-making, expectations, evaluation, feedback, frequency of communication of student clinical placement processes was created. Questions were reviewed by two program directors and piloted with a CPS not associated with the respective program to determine face and content validity. The survey was then emailed to all participants using Qualtrics. All surveys distributed were received. **Main Outcome Measures:** Means and SDs were calculated for demographic questions and SNA NetDraw analysis software was used to determine the density and reciprocity of each clinical placement question for each network. Density calculates actual connections compared to the number possible connections and is reported from 0-1, with higher scores representing every possible connection between every participant. Reciprocity (expressed as a %) evaluates the strength of the connection with each pair of participants who reported communicating with each other compared to total connected pairs in the CPS. **Results:** The PD and CEC are the most central figures in both on campus and off-campus CPS, with the PD communicating 32% more than the CEC for on campus and equal communication for off campus CPS. On-campus communications between all participants occurred 9% more than their off-campus counterparts. The highest density score (.24) was found for the off-campus CPS regarding student expectations. There was zero reciprocity in regards to student formal evaluation in both CPS. **Conclusions:** Our study found that CPS communication processes between participants are not occurring as anticipated. While this study represents a single CAATE program, further investigation of all accredited programs should be examined to determine the strength of communication and identify gaps in the communication patterns related to CPS.

Learner-Centeredness in Athletic Training Clinical Education Experiences

Kunkel LE, Wilson C, Vela L, Rast P: Texas Wesleyan University, Fort Worth, TX; University of Texas, Arlington, TX

Context: Educational evidence supports learner-centered practices in clinical educational experiences (CEE). The prevalence of learner-centeredness (LC) in athletic training (AT) CEE is unknown, as is the relationship between LC in CEE and preparedness to practice as an athletic trainer. **Objective:** To explore the prevalence of LC in AT CEE and the relationship between LC and learners' perceptions of preparedness for the profession. **Design:** Cross-sectional survey. **Setting:** An electronic survey was distributed to athletic trainers who successfully challenged the BOC exam within the prior 12 months. **Patients or Other Participants:** Four hundred ninety-three of 2,602 NATA members responded (19% response rate). Seventy-nine were ineligible for the study and another 171 did not complete the entire survey. The final 241 participants included 171 (71.3%) females, 69 males (28.8%). 203 participants (83.5%) attended a professional baccalaureate AT program, while 40 (16.5%) attended a professional master's program. **Interventions:** Participants completed the survey, considering the CEE they feel best prepared them as well as least prepared them to practice independently as a clinician. For each, participants were asked to indicate their perception of how the CEE prepared them to practice in each of the BOC domains, using a five-point Likert scale. Participants also completed a six question scale, the Modified Learner-Centeredness Scale (MLCS). The MLCS was modified from the medical literature and measures the learner's perceptions of preceptor LC. We assessed the MLCS validity with a principal component analysis, visual assessment of a scree plot, Velicer's Minimum Average Partial, and parallel

analysis (95% CI), all indicating one factor. Reliability was established with Cronbach's a (.97). **Main Outcome Measures:** Descriptive statistics determined prevalence of LC in AT CEE. To determine the relationship between LC and learners' perceptions of preparedness for AT, we used a Pearson *r* bivariate correlation between each of the BOC domains and MLCS score for each type of experience. **Results:** Mean scores for experiences which participants felt most prepared them for independent clinical practice (19.19 + 4.37) were significantly higher than those for experiences which participants felt least prepared them (9.22 + 5.65) ($t_{197} = 22.088$, $p < 0.001$). Pearson *r* correlation scores were statistically significant for all correlations between MLCS and each BOC domain ($p < .05$) in both types of experiences with r values ranging between .20 and .55. **Conclusions:** The study findings suggest LC approaches are being used during AT CEE, particularly in those learners felt most prepared them for independent clinical practice. In addition, perceptions of preparedness for independent clinical practice may be effected by preceptor LC.

Risk Factors of Low Back Pain in Female Collegiate Rowers

Gonzalez SL, Diaz AM, Detten M, Plummer HA, Michener LA: University of Southern California, Los Angeles, CA; Princeton University, Princeton, NJ

Context: Rowing athletes are at risk for overuse injuries such as low back pain (LBP). Evidence to define the physical impairments that are related to an increased the risk of LBP is needed to develop screening procedures and preventive interventions for rowers. The Functional Movement Screen (FMS™) has identified cut-off scores for the FMS™ composite scores of 14 – 17, indicating that those athletes with composite scores below these values were at risk of injury during the season. These cut-off values may not identify rowers at risk of LBP. **Objective:** Identify the FMS™ composite score that identifies rowers at risk for LBP, and identify if individual impairment measures differentiate between rowers with an identified risk of LBP. It was hypothesized that the FMS™ composite score would identify rowers at risk for LBP, and that these rowers would have functional impairment measures that differed from those with less risk of injury. **Design:** Prospective Cohort. **Setting:** Athletic training room. **Patients or Other Participants:** NCAA Division I female open rowers (n = 31; 19.9 ± 1.4 years; 163.6 ± 30.8cm; 84.1 ± 37.63). Inclusion criteria included free from injury at the time of testing. Coxswains were excluded. **Interventions:** The FMS™ was used for screening, and 6 individual impairment measures were used to assess impairments: Lower extremity Y-Balance test, closed kinetic chain dorsiflexion, plank test, sorensen test, and sit and reach test. Participants were tested prior to the start of the fall training season during pre-participation testing. Reports of LBP were then tracked in Sports Injury Monitoring System by the sports medicine staff during the fall season. LBP injuries were defined as any lumbar spine muscle, joint, tendon, bone, nerve, or disc related injury. The independent variable was injury status (injured vs. uninjured). **Main Outcome Measures:** Dependent variables were performance on the FMS™ and 6 individual impairment measures. Receiver operating characteristic (ROC) curve analyses were performed to determine cutoff points for those as risk of LBP for the FMS™ composite score. T-tests were performed to compare injured and uninjured rowers, significance set at $p \leq 0.05$. **Results:** Eighteen rowers suffered an episode of LBP during the season. The ROC analysis revealed the cutoff point of FMS™ composite score that differentiated injured versus uninjured was 11.5 (Area Under the Curve = 0.60; Sensitivity = 0.77, Specificity = 0.33), maximized for sensitivity. Rowers at risk of LBP, (FMS™ ≤ 11.5), had significantly lower plank test time (96.3 ± 51.8 s) than those with less risk (158.1 ± 82.7 s), mean difference = 61.6 s; 95% CI -111.2,-12.4; $p = 0.016$. **Conclusions:** FMS™ composite scores of ≤ 11.5 identified rowers at risk for developing LBP. The plank test is a measure of core endurance. Core endurance may be an impairment, that if addressed may serve as a prevention strategy to reduce LBP in rowers. Identification of at-risk athletes can enable the development of prevention strategies.

Subjective Disability Improvements Following Interventions Among Athletes With Low Back Pain

Sutherlin MA, Dames KD: State University of New York College Cortland, NY

Context: Context: Research among athletes with low back pain (LBP) is often difficult to interpret due to inconsistency or lack of reporting disability measures. The Oswestry low back pain disability questionnaire (OLBPDQ) was developed for LBP, but modifications and revisions of this questionnaire have been reported which could impact clinical interpretations. **Objective:** The purpose of this study was to examine subjective disability changes following interventions using variations of the OLBPDQ among athletes with LBP. **Data Sources:** A search was conducted across PubMed, SPORTDiscus, MEDLINE and CINAHL Plus databases up until November 2016. The search terms "low back pain or low back injury or lumbar spine" and "athlete or sport or ballet or baseball or basketball or bowling or crew or cross country or cycling or dance or diving or fencing or field hockey or football or golf or gymnastics or handball or ice hockey or lacrosse or martial arts or rifle or rowing or rugby or skiing or soccer or softball or swimming or tennis or track or volleyball or water polo or wrestling" and "disability or impairment or oswestry or oswestry disability index or ODI or OSW" were used to identify potential articles. Inclusion criteria consisted of articles that included any original, modified or revised version of the OLBPDQ, were written in English and consisted of an intervention that reported mean and standard deviation scores both before and after the intervention. **Study Selection:** Initially 1278 potential articles were identified before duplicates were removed. Fifteen articles included a version of the OLBPDQ

and athletes with LBP and twelve were excluded from the final analysis. **Data Extraction:** A single investigator assessed methodological quality using the Physiotherapy Evidence Database (PEDro) scale. Mean differences (MD), Cohen's *d* effect sizes, and 95% confidence intervals (95%CI) were calculated for each intervention. **Data Synthesis:** Three studies with four interventions were included for analysis with a mean PEDro score of 6/10. Surgical treatment had the largest decrease in LBP disability (MD=-28.80, *d* = -2.62, 95% CI (-3.03, -2.21)). Stabilization exercises of local and global spinal musculature (MD = -3.43, *d* = -0.63, 95% CI (-1.01, -0.26)) also showed a decrease in LBP disability. Conventional physical therapy (MD = -5.65, *d* = -0.50, 95% CI (-0.80, -0.20)) and physiotherapy (MD = -1.18, *d* = -0.22, 95% CI (-0.58, 0.15)) were inconsistent based on 95% CIs. **Conclusions:** Surgery and stabilization exercises were both effective at reducing LBP disability, but the impact of these interventions may be misrepresented due to modifications or revisions to the original OLBPDQ. Additionally, the lack of reporting disability measures among athletes with LBP limited the amount of studies included in this analysis. Based on the current findings, we recommend standardization of reporting disability measures and consistent utilization of specific disability questionnaires when evaluating intervention strategies among athletes with LBP.

Mechanical and Electrical Evaluation of Muscle Activity During Exercise in Individuals With and Without Low Back Pain

Mangum LC, Murray KP, Saliba SA: University of Virginia, Charlottesville, VA

Context: The determination of optimal treatment for patients with low back pain (LBP) can be difficult and understanding how prescribed exercises target muscles that may be dysfunctional in this pathological group is important. The lumbopelvic-hip muscles can play a role in low back pain and specifically the gluteals have not been studied in depth regarding their contribution to LBP. Determining if hip-targeted exercises activate gluteus maximus (GMax) and gluteus medius (GMed) differently in individuals with and without LBP can provide more information on the type of exercises that are most beneficial for this group. **Objective:** To compare GMax and GMed ultrasound thickness measures and peak electromyography (EMG) amplitude between participants with and without chronic LBP during nine lumbopelvic-hip rehabilitation exercises. **Design:** Descriptive laboratory study. **Setting:** Laboratory. **Patients or Other Participants:** 22 individuals (11 healthy: Age = 20.6 ± 1.6 years, Height = 166.9 ± 13.5 cm, Mass = 65.6 ± 15.0 kg, Sex = 9 F, 2 M; 11 LBP: Age = 20.8 ± 1.8 years, Height = 167.4 ± 8.5 cm, Mass = 66.3 ± 16.4 kg, Sex = 9 F, 2 M) volunteered to participate in this study. **Interventions:** Ultrasound images of GMax and GMed thickness were collected concurrently with surface EMG during a series of tabletop and standing exercises. **Main Outcome Measures:** Gluteal muscle thickness during exercises was normalized to quiet thickness to indicate a percentage of activity. Mean peak amplitude EMG was normalized to quiet tabletop or standing amplitude. Exercises were performed bilaterally in a clinical progression: side-lying hip abduction, tabletop active leg-lengthening, clams at 30° knee flexion, clams at 60° knee flexion, weight shifts, hip hitches, wall squats, single leg squats, and lateral band walking. Four MANOVAs were used to determine differences in groups in each exercise as measured by both ultrasound and EMG. Cohen's d effect sizes were also calculated with 95% confidence intervals (CI) to estimate magnitude of difference. **Results:** Healthy participants had a 16.2 ± 8.2% increase in ultrasound thickness for GMed during active leg-lengthening (P = .05, d = 0.87 [CI: 0.00, 1.75]) and a 17.1 ± 8.7% increase for clams at 30° of knee flexion (P = .02, d = 1.04 [CI:0.15, 1.93]) as compared to those with LBP. No significant differences were found in EMG between groups, however moderate effect size point estimates were present in all tabletop exercises for GMax EMG and during lateral band walking (.5 **Conclusions:** The LBP group exhibited less GMed thickness activity during only two exercises as measured via ultrasound with large effect sizes. This may indicate dysfunction in the smaller, stabilizing GMed for individuals with LBP in these tabletop tasks. Using ultrasound and EMG simultaneously can provide a more complete outlook on gluteal muscle activity in healthy and pathologic groups.

Education Best Practices Forum: Developing Effective Interprofessional Communication Skills

Thursday, June 29, 2017, 8:00AM-9:00AM, Room 360; Moderator: Jessica Rager, MS, ATC; Discussants: Kirk Armstrong, EdD, ATC; Stacy E. Walker, PhD, ATC, FNATA

Free Communications, Oral Presentations: Interprofessional and Collaborative Practice

Thursday, June 29, 2017, 10:45AM-11:45AM, Room 360; Moderator: R. Mark Laursen, MS, ATC

Collegiate Athletic Trainers' Perceptions of Interprofessional and Collaborative Practice

Hankemeier DA, Manspeaker SA: Ball State University, Muncie, IN; Duquesne University, Pittsburgh, PA

Context: Ability to engage in interprofessional and collaborative practice (IPCP) has been identified as one of the Institute of Medicine's Core Competencies required of all healthcare professionals. **Objective:** To determine the perceptions and perspectives of athletic trainers (AT) regarding IPCP and associated current practice patterns in the collegiate setting. **Design:** Cross-sectional. **Setting:** Online survey. **Patients or Other Participants:** 739 of 6313 (340 males, 397 females, 2 prefer not to answer, 10.97 ± 9.62 years clinical experience) athletic trainers in the collegiate setting participated (11.7% response rate). **Interventions:** Six constructs were assessed via a two section survey. Section 1 (α = .868) assessed *AT perceptions of working with other professionals* (Construct 1), *ATs engaged in collaborative practice* (Construct 2), *influences of collaborative practice* (Construct 3), *influences on roles, responsibilities, and autonomy in collaborative practice* (Construct 4). Participants rated statements in Section 1 on a 4-point Likert scale: strongly disagree (1), disagree (2), agree (3), and strongly agree (4). Section 2 (α = .831) assessed current practice patterns of those providing patient care and included the *impact of communication on collaborative practice* (Construct 5), and *patient involvement in collaborative practice* (Construct 6). Participants rated statements in Section 2 on a 4-point Likert scale in regard to their practice setting as: always true (1), sometimes true (2), not reflective of activity (3), and I am not familiar with the concept in this statement (4). **Main Outcome Measures:** Construct composite scores were calculated by adding all values and then averaging the scores back to the Likert scale. Higher scores in Section 1 indicated stronger perceptions of IPCP while lower scores in Section 2 indicated a more frequent occurrence of IPCP in clinical practice. The independent variable was reporting structure (athletic, medical, or educational model), while the dependent variables were participants' responses. Between-group differences were assessed with a Kruskall Wallace H-test with Bonferroni adjustment and Mann-Whitney *U* tests ($P < .05$). **Results:** Overall participants "agreed" with IPCP concepts for each construct (Construct 1 = 3.56 ± .30, Construct 2 = 3.36 ± .467, Construct 3 = 3.48 ± .39, Construct 4 = 3.20 ± .35). Practicing clinicians indicated that concepts of Constructs 5 and 6 (1.99 ± .46, 1.80 ± .50, respectively) are sometimes true in their setting. Clinicians reported that 42.09% percent of their patient care is performed in collaborative practice. ATs functioning in a medical model reported significantly lower scores for Construct 5 (1.88 ± .44) than those in the athletic model (2.03 ± .45, U = 19522.0, P = .001). **Conclusions:** ATs in the collegiate setting agree with the concepts of IPCP as beneficial to patient care, but are not consistently practicing in this manner. Consideration of moving to the medical model where more regular interaction with other healthcare professionals can occur should be sought to improve the frequency of IPCP.

Changes in Confidence and Understanding of Interprofessional Values and Teamwork Following an Ethics Workshop

Wallace SE, Manspeaker SA, Donoso Brown E: Duquesne University, Pittsburgh, PA

Context: The Interprofessional Education Collaborative has developed the Core Competencies to support interprofessional healthcare training which include, values and ethics, roles and responsibilities, communication, and teamwork. While several studies have focused on roles, communication and teamwork, fewer have focused on values and ethics. **Objective:** To determine the immediate impact of an ethics workshop on students from six health professions, including athletic training. **Design:** Quasi-experimental pre/post-workshop survey design. **Setting:** School of health sciences ethics based workshop. **Patients or Other Participants:** 219 students from six health professions including: 1) athletic training, 2) health management systems, 3) physical therapy, 4) physician assistant, 5) occupational therapy, and 6) speech language pathology participated in the workshop; 61 student (10 males, 51 females, 21.3 ± 3.3 years of age, 28% response rate) matched pre/post-survey responses were available for analysis. **Interventions:** Ethics workshop consisting of a modified jigsaw approach with case analysis. **Main Outcome Measures:** Student Perceptions of Interprofessional Clinical Education-Revised survey (SPICE-R, α = .83) plus five confidence questions related to perceived confidence in understanding and managing ethical situations on a 4-point Likert-scale; three open-ended response questions aimed to describe student perceptions of the workshop. Frequencies were used to describe the sample characteristics and the responses to the SPICE-R. Matched pre/post-survey responses were analyzed via Wilcoxon Signed Rank test. Open-ended responses were analyzed qualitatively via inductive

consensual coding with two primary coders and two auditors. **Results:** Students' pre/post responses reflected statistically significant changes in all items except the ability to describe the importance of respecting the dignity and privacy of patients while maintaining confidentiality in healthcare situations (Z = -1.34, P = .181). The number of positive changes in confidence related to workshop objectives ranged from 15 to 40, with a median of 25. The two items with the greatest number of positive changes were, 1) discussion of unique cultures, values and expertise of other professions (positive changes = 34/61) and, 2) identification of ways to manage ethical dilemmas (positive changes = 40/61). While no statistically significant changes were seen regarding perceived roles and responsibilities on the SPICE-R, students indicated that the workshop changed their understanding of other professions in the open-ended responses. Qualitative analysis revealed that students' perceived previous experience as influential during workshop participation. Students also identified that the workshop will likely influence future ways of thinking and actions that would support the management of ethical dilemmas. **Conclusions:** A single-day interprofessional workshop that focuses on ethics has the potential to increase student perceived confidence in managing ethical situations within an interprofessional team as well as have a positive influence on student perceptions of IPE. These results suggest that short workshops, including a modified-jigsaw approach, can be an effective mechanism for integrating IPE into athletic training curriculum.

Effects of an Interprofessional Living Learning Community With Athletic Training, Dietetics, Exercise Science and Nursing Students on Their Attitudes Towards College

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Context: Many athletic trainers work with other healthcare professionals. A living learning community (LLC) may prepare students for future interprofessional practice and improve their first year experience. **Objective:** Examine student attitudes towards college after participation in a LLC. **Design:** Prospective cohort study. **Setting:** Undergraduate college of nursing and health sciences in a small private midwestern university. **Patients or Other Participants:** Twenty-one athletic training, dietetics, exercise science and nursing students (8 males and 13 females) participated in a LLC. They lived in the same dorm, took three classes together and participated in monthly sessions that were educational, service or social. Sixteen of the 21 students completed all of the activities associated with the LLC. Thirteen of the 16 completed the survey (81.25%). **Interventions:** Students completed the Mid-Year Student Assessment (MYSA) electronically during the second semester. The survey is a reliable (Cronbach's alpha = 0.97) tool and used a seven point scale (1 = not at all true, 7 = completely true) to examine student attitudes towards college after completing their first term of enrollment. **Main Outcome Measures:** The dependent variable was participation in the LLC. Answers from the students in the LLC were compared to the general freshman population using one-sample t-tests. **Results:** The MYSA asked 29 questions regarding attitudes toward college; 9 of which related to goals of the LLC. Students had positive attitudes towards all nine of the items (mean > 6.0). Students in the LLC had a better attitude than the general population on only two items: 1) "I have found a potential career that strongly attracts me," [$t(12) = 2.65$, $p = 0.02$, 6.31 ± 0.86], and 2) "My instructors respect me as a person and treat me fairly," [$t(12) = 2.24$, $p = 0.045$, 6.38 ± 0.51]. There were no differences between the LLC students and non-LLC students on the follow items: 1) "Most of my instructors are very caring and dedicated," [$t(12) = 1.70$, $p = 0.12$, 6.15 ± 0.69], 2) "I am deeply committed to my educational goals, and I'm fully prepared to make the effort an sacrifices needed to attain them," [$t(12) = 1.75$, $p = 0.11$, 6.62 ± 0.65], 3) "I am strongly dedicated to finishing college-no matter what obstacles get in my way," [$t(12) = 0.99$, $p = 0.34$, 6.69 ± 0.63], 4) "I have made a firm decision to enter a certain occupation and have begun planning my life around that decision," [$t(12) = 1.09$, $p = 0.30$, 6.08 ± 1.34], 5) I have a very strong desire to continue my education and am quite determined to finish a degree," [$t(12) = 1.97$, $p = 0.07$, 6.77 ± 0.44], and 6) I like my instructors and feel they do a good job," [$t(12) = 1.23$, $p = 0.24$, 6.15 ± 0.80]. A ceiling effect could have affected the results. **Conclusions:** LLCs are a way to improve students' attitudes towards college and improve the first year experience. The students in this study had positive experiences and there may be long term benefits when they are practicing professional.

Perceived Drawbacks, Benefits, and Resources for Interprofessional and Collaborative Practice: Perspectives of Collegiate Athletic Trainers

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Context: An interprofessional and collaboration-based approach to patient care has been identified as a key component of healthcare by the Institute of Medicine. While this emphasis on interprofessional collaborative practice (IPCP) is expanding, little is known regarding the perceptions of collegiate athletic trainers in this area. **Objective:** To determine the perceptions of athletic trainers (AT) regarding drawbacks, benefits, and resources for IPCP in the collegiate setting. **Design:** Cross-sectional survey. **Setting:** Web-based questionnaire. **Patients or Other Participants:** Census sampling of 739 out of an invited 6313 (340 males, 397 females, 2 prefer not to answer, 10.97 ± 9.62 years clinical experience) athletic trainers in the collegiate setting (11.7% response rate). **Interventions:** Online questionnaire with Likert-scale items assessed perceptions ($\alpha = .868$) and practice patterns of IPCP ($\alpha = .831$); open-ended questions assessed the perceived challenges and drawbacks to participation in IPCP, benefits of IPCP, and resources perceived helpful to participating in IPCP. Only responses to open-ended questions are reported in this abstract. **Main Outcome Measures:** Participant responses were analyzed utilizing a general inductive qualitative approach by a two-member research team. Content analysis was used to consolidate textual responses into summary format through constant comparison. Key words and codes were assigned conceptual labels and then thematically categorized. Following thematization, the researchers debriefed and resolved discrepancies until all data were assigned consistently. Triangulation occurred via peer review and comparison of open-ended responses to Likert responses. **Results:** Challenges to IPCP included *time, knowledge related to IPCP* (knowledge of IPCP process, other healthcare professionals' knowledge of AT, and general knowledge of the roles of other healthcare professionals), and *opportunities to participate in IPCP*. Participants acknowledged drawbacks to participation in IPCP that were delineated into themes of *lack of defined roles within the IPCP team* and *communication*. Communication was further divided into sub-themes including: number of healthcare professionals on the team, turf wars/disagreements, and lack of communication. Perceived benefits to IPCP participation were identified as *improved patient care* and a *team approach to healthcare*. Resources anticipated as helpful to the IPCP process included *communication mechanisms* (accessibility to the interprofessional team, time/space, and general improved communication), as well as *interprofessional educational opportunities* (education about AT to other healthcare professionals and interprofessional learning sessions for healthcare professionals to learn from/alongside each other). **Conclusions:** ATs in the collegiate setting perceive communication as a resource for and challenge to participation in IPCP. ATs should aim to more thoroughly describe their skill set while also seeking to understand the roles of individuals on the healthcare team as improved communication may build trust and potentially improve patient outcomes. The findings of this study may be helpful in assisting ATs in the collegiate setting evaluate professional obstacles and/or opportunities for their own participation in IPCP.

Time-Related Changes in Musculoskeletal, Balance, and Physiological Characteristics in Naval Special Warfare Operators

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Context: Age-related decrements in musculoskeletal, balance, and physiological characteristics have been examined previously, with minimal changes across the early decades and greater losses in the later decades. There is limited research examining time-related changes within the same decade or in highly active, younger individuals. Naval Special Warfare (NSW) Sea, Air, Land (SEAL) and Special Warfare Combatant-craft Crewman (SWCC) Operators experience high levels of physical demand during tactical training and deployment. It is possible that extreme physical demand may accelerate the decline in these characteristics in this population, increasing risk of injury and compromising force readiness. **Objective:** To examine if musculoskeletal, balance, and physiological characteristics change over a two-year period in SEAL and SWCC Operators. **Design:** Cohort study. **Setting:** Sports Medicine Research Laboratory. **Patients or Other Participants:** A total of 61 SEAL and SWCC Operators (age: 25.98 ± 4.89 years; height: 178.31 ± 6.23 cm; mass: 82.99 ± 10.28kg) participated. **Interventions:** Participants completed laboratory testing assessing muscular strength, flexibility, balance, and physiological characteristics at baseline and 2-year (±6 months) follow-up. **Main Outcome Measures:** Isokinetic shoulder internal/external rotation (SIR/SER), trunk flexion/extension, and knee flexion/extension strength were assessed using an isokinetic dynamometer (60°/s, 5 repetitions each), and average peak torque was normalized to body weight (%BW). Flexibility of the shoulder (passive SIR, SER, and posterior shoulder tightness) and hamstrings (active knee extension) were assessed using a digital inclinometer (average of 3 measurements). Dynamic balance was assessed during a single leg jump-landing (5 trials) using a force plate (1200Hz). Physiological assessments included body composition (air-displacement-plethysmogrpahy: BF%), mass, and fat-free mass (FFM); Wingate test (anaerobic power/capacity: Watts/kg); and a graded treadmill running protocol (aerobic capacity). Data were assessed for normality using Shapiro-Wilk tests. Paired t tests or Wilcoxon signed-rank tests were performed for normally and non-normally distributed variables, respectively, and Bonferroni corrections applied as needed. Statistical significance was set at $p<0.05$, two-sided *a priori*. **Results:** Participants had significantly greater body mass (82.99 ± 10.28 kg vs. 85.21 ± 11.76 kg, $p \leq 0.001$), less SIR flexibility (56.84 ± 7.04° vs. 53.48 ± 8.96°, $p = 0.002$), greater BF% (16.23 ± 5.24% vs. 18.22 ± 5.78%, $p = 0.003$), and lower anaerobic capacity (8.93 ± 0.98 W/kg vs. 8.74 ± 0.98 W/kg, $p = 0.019$) at follow-up. No significant differences were found in the remaining variables. **Conclusions:** Over a two-year period, Operators demonstrated significant increases in body mass and fat, without change in FFM, along with decreases in shoulder flexibility and anaerobic capacity. Previous research in this population has correlated increased body fat with increased injury incidence and found that the shoulder is the most common injury location. Task and demand analyses of tactical training have shown that most operational tasks involve short duration, high intensity bouts of activity; therefore, declines in anaerobic capacity may affect operational performance. Human performance interventions should focus on maintaining body composition, shoulder mobility, and anaerobic capacity over an Operator's tactical lifecycle. Funded by ONR Award #N000141110929.

Personal Protective Equipment Diminishes Static and Dynamic Balance in Firefighters

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Context: Balance and postural control are essential to engage in both routine daily activities as well as to perform specific occupational tasks. Balance and postural control are regulated by the visual, vestibular, and somatosensory systems of the body. When a change occurs in the center of gravity, or one of the systems is disrupted, the likelihood of the individual having a slip or fall increases. Firefighters wear personal protective equipment (PPE) to protect them from fire, smoke, and chemicals that they encounter in workplace duties. The firefighter's PPE is standard turnout gear which includes the external coat and pants, gloves, a flash hood, helmet, and a self-contained breathing apparatus (SCBA). With the addition of this PPE, the center of gravity is changed as is the equilibrium of the body, both of which have been shown to lead to more slips and falls. Slips, trips, and falls are the leading mechanism of injury in the fire service, accounting for approximately 23% of all injuries at the fireground. **Objective:** To determine the effects of PPE on static and dynamic balance in firefighters. **Design:** Repeated measures, single cohort. **Setting:** Fire stations. **Patients or Other Participants:** Forty-one male firefighters (age = 37 ± 8.1 y; height = 182.7 ± 8.4 cm; mass = 98.8 ± 14.3 kg; years of experience = 11.0 ± 6.2 y; leg dominance = 34 R, 7 L; FADI = 98.7 ± 2.6 points) completed this study. **Interventions:** Participants completed the static and dynamic balance tasks in station attire (no-PPE) and while donning firefighting specific PPE (+PPE) (mass of PPE = 23.8 ± 2.1 kg). **Main Outcome Measures:** We measured static balance using a multi-axial force platform with measures of rectangular displacement area and average displacement velocity during three trials in the double-legged and dominant single-legged stance. We measured dynamic balance using the Y Balance Test™ with average measures of three trials in the anterior, posteromedial, and posterolateral reach for each leg. We utilized separate paired-sample t-tests to compare the no-PPE and +PPE conditions on the measures of interest. **Results:** Significant negative alterations in dynamic balance with the addition of PPE were found for reaches in the right anterior (mean difference = -3.4 ± 3.1 cm; $p < 0.001$), left anterior (mean difference = -3.9 ± 3.6 cm; $p < 0.001$), right posterolateral (mean difference = -7.0 ± 6.1 cm; $p < 0.001$), left posterolateral (mean difference = -5.3 ± 5.5 cm; $p < 0.001$), right posteromedial (mean difference = -4.1 ± 6.9 cm; $p < 0.001$), and left posteromedial (mean difference = -3.9 ± 6.7 cm; $p = 0.001$) directions. However, no significant changes were identified for measures of static balance with the addition of PPE. **Conclusions:** The addition of firefighting specific PPE negatively impacts dynamic balance. When implementing prevention programming or functional rehabilitation, athletic trainers working with tactical athletes should design and execute programming which includes activities in occupation-specific PPE to maximize readiness, prevent injury, and improve technical performance.

Impact of Previous Injury on Musculoskeletal and Physiological Characteristics in Naval Special Warfare Operators and Students

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Context: Previous musculoskeletal injury (MSI) is consistently reported as a risk factor for injury recurrence, possibly due to injury-related musculoskeletal and physiological decrements. However, it is unknown if musculoskeletal/physiological deficits exist in Naval Special Warfare (NSW) Operators and Students who have sustained a MSI within the past year and have been deemed fit for full duty. Identifying which of these modifiable characteristics are affected following injury would enable clinicians and strength and conditioning specialists to better design and implement interventions with the intent of reducing recurrent injuries. **Objective:** To examine the impact of injury within the past year on musculoskeletal and physiological characteristics in NSW Operators and Students deemed fit for full duty. **Design:** Cross-sectional study. **Setting:** Sports Medicine Research Laboratory. **Patients or Other Participants:** A total of 1221 NSW Operators and Students (age: 27.24 ± 6.30 years; height: 178.62 ± 6.46 cm; mass: 85.14 ± 9.27 kg) participated. **Interventions:** Participants completed laboratory testing to assess muscular strength, flexibility, and physiological characteristics. Self-reported MSI history (365 days prior to laboratory testing) was obtained and participants were stratified based on injury status by region (upper extremity [UE], trunk, and lower extremity [LE]). **Main Outcome Measures:** Average peak torque normalized to body weight (%BW) was

calculated for isokinetic shoulder internal/external rotation (SIR/SER), trunk flexion/extension, right/left trunk rotation, and knee flexion/extension strength, which were assessed using an isokinetic dynamometer (60°/s, 5 repetitions each). Shoulder (passive SIR, SER, and posterior shoulder tightness) and hamstring (active knee extension) flexibility were measured using a digital inclinometer (average of 3 measurements). Body composition (BF%: air-displacement-plethysmogrpahy), anaerobic power/capacity (Watts/kg: Wingate test), and aerobic capacity (graded treadmill running protocol) also were assessed. All data were assessed for normality using Shapiro-Wilk tests. Independent samples t tests or Mann-Whitney U tests were performed for normally and non-normally distributed variables, respectively. Statistical significance was set at $p < 0.05$, two-sided *a priori*. **Results:** Participants with UE injury demonstrated significantly less SER strength than non-injured participants (right: Injured: 43.39 ± 7.24% BW vs. Non-injured: 45.13 ± 7.67% BW, $p = 0.014$; left: Injured: 41.19 ± 7.13% BW vs. Non-injured: 42.66 ± 7.08% BW, $p = 0.024$). Participants with trunk injury demonstrated significantly better aerobic fitness as measured by percent of VO_{2max} at lactate threshold compared to non-injured participants (Injured: 83.01 ± 6.38%; Non-injured: 79.51 ± 7.40%, $p = 0.004$). No musculoskeletal/physiology differences were found between participants with and without LE injury or in the remaining variables for UE and trunk injury comparisons. **Conclusions:** Minimal musculoskeletal and physiological differences were found between Operators with and without self-reported MSI, potentially indicating complete recovery from injury. Operators with UE injury demonstrated significantly less shoulder external rotation strength than those with no UE injury, although this difference may not be clinically meaningful. Operators with trunk injury demonstrated better aerobic fitness, which may due to injury related training adjustments away from weightlifting and towards cardiovascular training/weight management.

An Examination of the Triple Hop for Distance as a Predictor of Lower Extremity Performance in Firefighter Equipment

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Context: Structural firefighters are subject to job-related physical demands that predispose them to acute and chronic injury. In 2015, 52.7% of all fireground injuries were sprains, strains and muscular pain. While improvements in personal protective equipment (PPE) have decreased injuries and illnesses due to smoke inhalation, cuts, and burns, the addition of PPE may place firefighters at an increased risk for musculoskeletal injury. Screening for lower extremity (LE) power and strength while wearing PPE using physical performance tests would be helpful for healthcare providers working with tactical athletes to aid in the design of injury prevention programs. No valid tool currently exists measure LE power and strength in firefighting PPE. **Objective:** To determine the extent to which the Triple Hop for Distance (THD) predicts performance on clinical measures of LE power and strength while donning firefighting PPE. **Design:** Single cohort. **Setting:** Research laboratory. **Patients or Other Participants:** Twenty-eight healthy participants (male = 19, female 9; age = 23.0 ± 2.4 y; height = 175.48 ± 11.32 cm; mass = 78.72 ± 14.16 kg; mass in PPE = 89.97 ± 14.63 kg; leg dominance: right = 36, left = 2) without experience as a firefighter volunteered. **Interventions:** Participants completed the three trials of the THD in firefighter PPE (mass of PPE = 11.25 ± 1.00 kg) on both the dominant and non-dominant legs. **Main Outcome Measures:** The dependent variables included LE power (maximal vertical jump height (cm)) on a jump mat, and LE strength of the quadriceps ($Quad_{60}$, $Quad_{180}$) and hamstring muscles (Ham_{60}, Ham_{180}) (peak torque (Nm)) on an isokinetic dynamometer at 60°/s and 180°/s, respectively. Statistical analyses included descriptive statistics and simple linear regression analyses. **Results:** THD was a strong predictor of LE power, explaining 64.7% of the variance ($p < 0.001$) in the dominant limb and 62.0% of the variance in the non-dominant limb. THD also predicted dominant limb LE strength, accounting for 25.7% of the variance in Ham_{60} ($p = 0.006$), 29.3% of the variance in Ham_{180} ($p = 0.003$), 22.6% of the variance in Ham_{60} ($p < 0.01$), and 27.5% of the variance in $Quad_{180}$ ($p = 0.004$). The THD also predicted non-dominant limb LE strength, accounting for 45.9% of the variance in Ham_{60} ($p < 0.001$), 30.6% of the variance in Ham_{180} ($P = 0.002$), 33.8% of the variance in $Quad_{180}$ ($p = 0.001$), but was not strong or significant in $Quad_{60}$, accounting for only 1.0% of the variance ($p = 0.612$). **Conclusions:** The THD is a strong and valid predictor for clinical measures of LE power and strength in firefighter PPE. The validation of this functional performance test may assist clinicians in identifying risk factors associated with LE injuries in tactical athletes. Future research should evaluate the feasibility of integrating the THD during the work performance evaluation for firefighters.

Examination of Sports Nutrition Knowledge and Prevalence of Disordered Eating Among ROTC Cadets

Connell SA, Torres-McGehee TM, Emerson DM, Jenson M, Ferland L: University of South Carolina, Columbia, SC; University of Kansas, Lawrence, KS

Context: The Reserve Officers' Training Corps (ROTC) is a hybrid population of elite athletes, general population, and military expected to perform at an elite level both mentally and physically. It is important to understand sport nutrition knowledge and eating habits to identify individuals at risk for disordered eating in order to promote healthier performance. **Objective:** To examine the relationship between sports nutrition knowledge (SNK) and the prevalence of disordered eating (DE) among male and female ROTC cadets. **Design:** Non-experimental, cross-sectional design. **Setting:** Collegiate ROTC **Patients or Other Participants:** Participants were 77 ROTC Cadets (ages 18-35; male = 53; females = 24) from 2 southeastern universities. Participants represented Army, Navy, Airforce, and the Marines. Interventions: ROTC cadets were categorized by gender (male and female). **Interventions:** ROTC cadets were categorized by gender (male and female), and participants completed an online survey. **Main Outcome Measures:** As part of a larger study, data collected were: 20 sport nutrition questions (basic nutrition, supplements and performance, weight management, and hydration), confidence scores in correctness of answers (1 = *not at all confident* to 4 = *very confident*), and Eating Attitudes Test (EAT-26). *Adequate SNK* was defined as an overall score > 75/100%. Crosstabulations and chi square analyses examined the relationship and distribution between genders for DE risk. Descriptive statistics for average scores and standard deviations for SNK scales were calculated. **Results:** ROTC cadets had overall inadequate SNK (55.26% + 13.1). ROTC cadets had adequate SNK in the domain of supplementation (76.36% + 22.18) with a higher confidence in correct (3.08 + .21) than incorrect (2.37 + .26) answers which indicates the participants understood the material. Basic nutrition (34.81% + 17.89) was the weakest domain, followed by weight management (51.68% + 19.29) and hydration (58.18% + 21.81). ROTC cadets overall had above average confidence in both correct (2.68 + .56) and incorrect (2.43 + .41). Estimated prevalence for DE risk for ROTC cadets was 26% (males 15.6%, females 10.4%). ROTC cadets self-reported binge eating (11.7%); vomiting to control weight gain (1.3%); use of laxatives, diet pills, or diuretics (10.4%); exercise to control weight (6.5%); and lost 20 pounds or more in the last 6 months (5.2%). There was no significant relationship between gender and risk for DE ($p = .322$). There was, however, a statistical significance indicating a higher usage of laxatives, diet pills, or diuretics among females than males ($p = .043$). **Conclusions:** DE risk prevalence among ROTC cadets is similar to elite endurance athletes and higher than the general population. There was no significant difference between genders. SNK in ROTC cadets is inadequate which may contribute to the high risk of DE. Nutritional programming and improved education may decrease the risk of unhealthy pathogenic behaviors and in turn improve overall physical and mental wellness.

Free Communications, Oral Presentations: Influence of Injury on Psychosocial Factors

Thursday, June 29, 2017, 1:30PM-2:30PM, Room 360; Moderator: James Mensch, PhD, ATC

Injuries Are Such a Downer: A Review of Depressive Symptoms Among Collegiate and Professional Athletes

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Context: The physiological responses to athletic injury among elite athletes have been extensively researched. To date, few studies have examined the psychological responses to those injuries and the potential for an increased risk of experiencing depressive symptoms. **Objective:** Identify, evaluate and synthesize the published literature regarding the prevalence and nature of depressive symptoms among collegiate student-athletes and elite athletes across various self-report symptom scales. **Data Sources:** A search of PubMed and SPORTDiscus was conducted in September 2016 to discover all relevant published literature. Combinations of the following search terms were utilized: depression, depressive symptoms, psychology, athlete, injury, concussion, musculoskeletal. Reference lists of identified articles were manually scanned for supplementary articles. **Study Selection:** Studies included in this review met the following inclusion criteria: (1) study subjects were collegiate student-athletes or professional athletes, (2) the study reported quantitative or qualitative results regarding depressive symptoms, mental health, or psychological assessment, and (3) the study was published in English. **Data Extraction:** The initial database searches identified approximately 500 articles. These articles were then screened against the inclusion criteria. This process identified 28 articles meeting all inclusion criteria. Each of these articles was examined and relevant data were entered into categories within a data matrix. **Data Synthesis:** Twenty-eight articles reported depressive symptom prevalence among subsections of athletes (e.g. gender, sport participation level, injury status). Due to the heterogeneity of study designs and outcomes, the author was unable to statistically evaluate or compare results across studies. Most of the studies employed a cross-sectional design (n = 13, 46.4%), followed by cohort studies (n = 8, 28.6%), systematic reviews (n = 4, 14.2%), qualitative methods (n = 2, 7.1%), and a case-control study (n = 1, 3.5%). Regarding the administration of symptom scales, the Center for Epidemiologic Studies Depression Scale (CES-D) was used most frequently (n = 11, 39.2%) followed by the Profile of Mood States (POMS) (n = 4, 14.3%) and Beck Depression Inventory (BDI) (n = 3, 10.7%). **Conclusions:** Prevalence rates of depressive symptoms ranged from 15.0% to 32.3% among athletes across multiple symptom scales. Several factors appeared to pose an increased risk of depressive symptoms. Female athletes were seen to be at an increased risk of depressive symptoms compared to male athletes. Injured athletes have been found to experience greater levels of depressive symptoms than uninjured athletes. Additionally, injury type (concussion versus musculoskeletal) and length of recovery time both affected levels of depressive symptoms. In summary, depressive symptom prevalence estimates among collegiate and professional athletes varied across measurement scales. It is important to determine the most valid and reliable symptom scale to establish a standardized approach for athletic trainers to assess depressive symptoms. Athletic trainers may also consider tailoring psychological interventions to individual athletes based on the established risk factors.

Pain Severity, Pain Interference, and Athlete Fear Avoidance Are Related to Acute Injury Rehabilitation Time in Athletes

Porter ED, Dover GC: Concordia University, Montreal, Quebec, Canada

Context: Pain related fear and fear avoidance contribute to the development of chronic pain and longer rehabilitation times in the general population. Recent evidence suggests that fear avoidance might be associated with increased rehabilitation times in athletes with ACL reconstructions but there is little research on other injuries. **Objective:** The purpose of this study was to measure pain related fear and return to competition time in athletes who have suffered an acute musculoskeletal injury. **Design:** A single group pre-post test study. **Setting:** University athletic facilities. **Patients or Other Participants:** Thirty-three student-athletes (25 males and 8 females, age = 21.6 ± 1.5 years, height = 178.3 ± 10.1 cm, mass = 88.8 ± 22.5 kg, years of participation in sport = 13.7 ± 4.4 years) participated in this study. Athletes competed in football, rugby, soccer, or hockey. **Interventions:** Within 24 hours of suffering a musculoskeletal injury, participants completed a battery of questionnaires. The questionnaires assessed pain severity (BPI-PS), pain interference (BPI-PI), pain disability (PDI), and depression. **Main Outcome Measures:** Pain related fear and fear avoidance was measured by the Pain Catastrophizing Scale, Tampa Scale of Kinesiophobia, Fear Avoidance Beliefs Questionnaire and the Athlete Fear Avoidance Questionnaire (AFAQ). Function was measured by a self-report scale and return to competition was measured in days once the athlete returned to competition with no restrictions. **Results:** There was a significant improvement in pain and function from injury to return to competition (pain 6.6 ± 1.5 and 1.7 ±

1.9, p < .001; function 46.9 ± 21.9, 9.3 ± 8.1, p < .001). In addition, all participants experienced a decrease in pain severity (4.4 ± 1.5, 0.87 ± 0.92, p < .001), pain interference (3.3 ± 1.7, 0.39 ± 0.56, p < .001), athlete fear avoidance (22.9 ± 5.5, 13.7 ± 3.6, p < .001) fear avoidance (19.5 ± 5.7, 8.5 ± 6.7, p < .001), kinesiophobia (39.6 ± 7.8, 31.7 ± 6.7, p < .001) and pain catastrophizing (13.4 ± 8.7, 4.4 ± 6.4, p < .001) from baseline to return to competition. Pearson correlations identified significant relationships between baseline pain disability, pain severity, pain interference, athlete fear avoidance, and function, with return to competition (PDI r = 0.356 p = 0.042; BPI-PS r = 0.352 p = 0.044; BPI-PI r = 0.547 p = 0.001; AFAQ r = 0.424 p = 0.014; function r = 0.393 p = 0.024). The regression analysis indicated a significant model, which accounted for 43.4% of the variance of return to competition time. **Conclusions:** While there is a well-established improvement in pain and function after injury rehabilitation, results from our study indicate that there is also a significant improvement in pain related fear. In addition, our data suggests that baseline pain, athlete fear avoidance, and function are related to return to competition time. It is possible that using baseline measures of pain and athlete fear avoidance could predict rehabilitation times in athletes. More studies are needed to assess the prediction capability of the AFAQ, which may be an important tool for clinicians to use during their initial assessment to see if psychological considerations need to be addressed during rehabilitation.

The 6-Month Progression of Pain Catastrophizing in an Acute ACL Population

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Context: The pain catastrophizing scale (PCS) is a tool that helps clinicians identify patients that may have a difficult time accepting their injury and coping with the pain. Patients that score high (>30) on the PCS demonstrate qualities such as pain preoccupation, dramatization, and helplessness, all counterproductive for successful rehabilitation. Limited research has focused on pain catastrophizing in an acute injury population. **Objective:** The purpose of this study was to evaluate pain catastrophizing via the PCS during the first six months following index anterior cruciate ligament reconstruction (ACL-R) in a young, active population. We hypothesized that scores on the PCS would remain stable in ACL-R patients. **Design:** Prospective longitudinal. **Setting:** Orthopedic Sports Medicine Clinic. **Patients or Other Participants:** A total of 40 patients (23M/17F, age 22.34 ± 4.15 years, BMI 23.9 ± 3.1) undergoing index ACL-R participated. **Interventions:** This data is part of a Multicenter Orthopaedic Outcome Network (MOON) randomized trial evaluating early anti-inflammatory treatment after ACL injury. **Main Outcome Measures:** A repeated measures ANOVA was used to examine PCS over six time points. The dependent variable was the PCS and the independent variables were sex and time. **Results:** Significant differences were observed between initial (9.9 ± 9.9) and 2 weeks post-injury (4.1 ± 6.6), and initial and day of surgery (2.4 ± 3.9), demonstrating decreasing scores on the PCS from onset of injury to surgery (P < 0.005). Following surgery (6.5 ± 5.7) PCS scores were significantly increased compared to day of surgery (P = .009). PCS scores were decreased at 6-months (.46 ± 1.5) when compared to 2 weeks post-surgery (P = .000). There was no sex difference. **Conclusions:** Pain catastrophizing scores respond dynamically following an acute trauma such as an ACL tear in a young, active population. Pain catastrophizing is often thought to be static; you are or are not a pain catastrophizer. This data demonstrates that in fact pain catastrophizing scores fluctuate and may vary according to tissue insult in an acute injury population. Additionally, this data highlights the clinical importance of standardized timing when collecting PROs. If clinicians are interested in evaluating a pre-operative intervention PROs should be administered immediately following acute injury. To evaluate post-surgical improvement the PROs should be collected as close to surgery as possible. A delay in collecting PROs may result in diminished overall change scores due to the rapid, significant improvement in symptoms seen in this population. Prompt collection of patient reported outcomes will allow for an accurate illustration of the patients response to injury or surgical intervention and will help clinicians provide evidence-based care. These findings may be different for the use of PROs and PCS specifically in chronic conditions such as osteoarthritis or cartilage defects.

Fear of Re-Injury Remains High in Adolescent Female Athletes Following Anterior Cruciate Ligament Reconstruction and Full Return to Sport

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Context: Fear of re-injury, or kinesiophobia, can influence the ability to return to sport following anterior cruciate ligament reconstruction (ACL-R). Kinesiophobia improves in adults following rehabilitation. It is unknown if fear of re-injury remains high after return to sport in adolescent female athletes following ACL-R or if it is related to other subjective and clinical findings. **Objective:** To compare kinesiophobia levels in adolescent female athletes with and without a history of unilateral ACL-R and to examine the association between kinesiophobia levels, self-report function and clinical measures. **Design:** Cross-Sectional Correlation **Setting:** Research Laboratory **Patients or Other Participants:** Twenty-two adolescent female athletes with a history of unilateral ACL-R (age = 16.68 ± 1.55 years, height = 166.80 ± 6.04 cm, mass = 61.08 ± 8.78) and 25 matched controls (age = 16.91 ± 1.23 years, ht = 170.22 ± 7.40 cm, mass = 63.32 ± 7.59 kg). All ACL-R participants had made a full return to their sport prior to testing (8.18 ± 2.48 mos). **Interventions:** Subjective questionnaires for fear of re-injury (TSK-11) and the knee injury osteoarthritis outcomes score (KOOS) were collected. Isometric quadriceps strength was assessed with a handheld dynamometer and a single-leg double hop (SLDH) task was performed bilaterally. The SLDH task consisted of two consecutive single-leg forward hops in an attempt to cover as much distance as possible. **Main Outcome Measures:** Subjective measures included the TSK-11 and two KOOS subscales; function in sport and recreation (Sport), knee related quality of life (QOL). Isometric strength data was averaged over three trials and normalized using an allometric scaling function. Limb symmetry indices (LSI) for hop distance were calculated from the SLDH [(Injured/Uninjured)*100]. An independent samples t-test was performed to compare TSK-11 values between groups (ACL-R, Control). Within the ACL-R group, pearson correlations were computed to assess the relationship between TSK-11, quadriceps strength and SLDH LSI. Spearman ranked correlations were computed to assess the relationship between TSK-11, KOOS Sport, and KOOS QOL. **Results:** The ACL-R group (19.91 ± 5.10) had greater fear of re-injury after full return to sport compared to the Control group (16.88 ± 4.46) ($t_{(45)}$ = -2.174, p = 0.035). Fear of re-injury (TSK-11) was not associated with quadriceps strength (18.34 ± 3.59, r = 0.01, p = 0.97), SLDH LSI (95.23 ± 6.05, r = 0.12, p=0.58), or KOOS Sport (85.23 ± 15.77, r = -0.09, p = 0.69). However, the TSK-11 was negatively correlated with KOOS QOL (73.86 ± 23.44, r = -0.62, p = 0.002) such that greater fear of re-injury was associated with diminished knee related quality of life. **Conclusions:** Results of this study demonstrate a greater fear of movement or re-injury is still present in adolescent female athletes with a history of ACL-R. This heightened fear of re-injury is associated with diminished knee related quality of life. Adolescent females are at the highest risk for ACL injury and subsequent injury after return to sport. Continued efforts must be made to identify the most effective means of improving fear of re-injury even after return to sport.

A Case of Morel Lavallée Lesion of the Lower Leg: A Case Report

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Background: A healthy, 21 year old Division I football defensive line (body mass = 111.5 kg; height = 193 cm) presented to the athletic trainer complaining of pain and swelling over the proximal 2/3rd anteromedial aspect of his lower right leg, after being "cleated" during the game three days prior. The athlete finished the game with minimal discomfort, but stated it had "swelled a lot since the game". The athlete reported no unusual sensation to the area. Physical examination revealed a large hematoma and ecchymosis over the anteromedial aspect of lower right leg. A point tender, soft, fluid-like pocket was also present on the anteromedial aspect of the lower leg. There were no signs of a fracture. The original diagnosis was a lower leg hematoma. After three weeks, with no decrease in the fluid collection, the athlete was referred to the team physician. **Differential Diagnosis:** Possible differential diagnosis includes: fibular fracture, soft tissue seroma, muscular strain or tear, and intramuscular hematoma. Radiography, diagnostic ultrasound and MRIs were used to rule out these conditions. **Treatment:** Following the initial injury, the athlete was treated with massage and ice bag once a day. Three weeks post injury, the athlete met with the team physician. The physician's initial physical examination revealed a superficial fluid filled collection with slight bruising around the area, with minimal discomfort and no muscular deficiencies. The physician encouraged the athlete to continue massage, ice, and begin strengthening exercises. A week later and no change, a tib-fib radiograph and knee MRI were completed. Right knee radiography results revealed a normal alignment of osseous structures and no obvious fracture, dislocation or joint effusion. Right knee MRI results revealed an organized collection of fluid in the subcutaneous tissue, measuring 6.4 x 3.7 x 4.2 cm confirming a Morel Lavallée Lesion. No osseous structure or muscular involvement. Following the diagnoses, the athletic trainer continued to massage the area and provide ice. The athlete was provided a compression sleeve and monitored closely for signs of infection or concerns requiring aspiration. With continued monitoring, the fluid collection resolved, without aspiration, and he finished the season with no further complications. **Uniqueness:** Morel Lavallée Lesion are posttraumatic hemolymphatic collection between subcutaneous soft tissue and muscle and is commonly seen in motor vehicle accidents. However, in this case it occurred during a football game while being stepped on. Additionally, this type of injury occurs most commonly on the pelvis, greater trochanter, or knee. In this case, the athlete was stepped on and the lesion occurred to the proximal 2/3rd anteromedial aspect of his lower right leg. Though, the incidence rate of the calf/lower leg is approximately 1.5%, it is vital for Athletic Trainers to be aware of this condition. Other case studies of Morel Lavallée have been reported in the literature, however, none have been described in the lower leg. **Conclusions:** Athletic trainers see ecchymosis and hematomas regularly. However, it is important to be aware of other signs and symptoms to rule out Morel Lavallée. Furthermore, it is vital for the athletic trainer to make the appropriate referral to avoid more serious side effects. In this case, proper referral led to proper diagnosis, which allowed for better treatment for the athlete.

A Proximal Tibial Metaphyseal Stress Fracture in a Collegiate Distance Runner: A Case Report

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Background: A 21-year-old distance runner complained initially complained of left, medial knee pain over her pes anserine tendon attachment following a run on 1/29/16. The pain was intermittent during running, and was still present when the athlete reported to the athletic training room for evaluation. Initial evaluation reveled pain with hip flexion and external hip rotation. Treatment resolved the issue. She was initially told to rest over the weekend and was given a 24-hour patch with dexamethasone. This resolved the issue, and the episode was closed on 2/3/16. After a 3k and 5k race on 2/12 and 2/13, the athlete complained of the same pain. The AT staff treated with pulsed ultrasound, dexamethasone patch, and lower extremity massage. Pain went into remission but came back again on 3/9/16. At this time she was referred for an MRI to rule out stress fracture of the proximal tibia. The orthopaedic surgeon suggested that tendonitis in the area was likely, but he wanted to rule out a stress fracture. MRI revealed a proximal tibial stress fracture and the athlete was scheduled for a follow up on 4/6/16 and removed from running. **Differential Diagnosis:** Pes anserine tendinitis, patellar tendonopathy, tibial stress fracture. **Treatment:** The athlete was treated with rest, rehabilitation exercises, and followed an incremental running progression starting on 6/13. **Uniqueness:** The epiphyseal plates of a 21-year-old female are closed; therefore presenting with a stress fracture at this location is rare. Biomechanically, distance runners attenuate forces at the middle one-third of the tibia, making this the most common

location for stress-related injuries. **Conclusions:** The clinical implications of this case show that proximal tibial stress fractures in mature athletes are rare, but they should not be overlooked in the evaluation process. In this case, the injury presented as a common bursal pathology.

A Unique Lisfranc Dislocation in a Collegiate Football Player

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Background: During a college football game, a healthy 22 year-old (184.4 cm, 97.5 kg) male wide receiver with no reported history of previous right foot injury jumped to catch a ball. Upon landing on the right foot in a plantarflexed position, an axial load was placed on the foot when a defender landed on the involved lower leg. On field evaluation performed by the athletic trainer found the foot plantarflexed with significant bony deformity and tenting of the skin at the midfoot. The patient was in severe pain and unable to move the foot or bear weight. He was neurovascularly intact distally. EMS was activated and the patient was stabilized and transported to the hospital emergency department. **Differential Diagnosis:** cuboid fracture, navicular compression fracture, metatarsal fracture, compartment syndrome of the foot. **Treatment:** Plain radiographs of the foot demonstrated a homolateral Lisfranc dislocation. A computed tomography scan was obtained to further evaluate the severity of dislocation and rule out fracture. CT revealed a purely ligamentous injury. Due to concerns for potential compartment syndrome, the patient underwent an emergent open reduction and internal fixation of the unstable Lisfranc joint using Kirschner wire and was placed in a post-mold splint on non-weight bearing (NWB) status. Four days following the procedure, the patient was evaluated in the surgeon's office where radiographs were obtained demonstrating stable fixation and anatomic reduction. He was placed in a short leg cast and continued on NWB status. The cast was removed 17 days following the procedure and transition was made to a cam walking boot where he remained NWB. The patient began the rehabilitation process at four weeks after surgery that included soft tissue, scar, and joint mobilizations. Joint mobilizations occurred at the talocrural, subtalar, and cuneiform joints in addition to all rays of the midfoot. Ankle range of motion was addressed through all planes and strengthening exercises including hip and knee resistance weights were initiated. Six weeks after surgery, the Kirschner wire was removed and the patient was released to weight bearing as tolerated in the cam walking boot. The patient quickly denied pain with weight bearing and rehabilitation progressed to closed kinetic chain strengthening and single leg proprioception. This included single leg stance and reach exercises, standing BAPS, rocker board, and karaoke drills. At the conclusion of the third week of rehabilitation, the patient was able to ambulate without complaints of pain in a regular shoe. The patient progressed to full weight bearing on the right lower extremity and was able to demonstrate an even stance time bilaterally with a full weight bearing gait pattern. Light running and sport specific drill progressions were initiated at 10 weeks following surgery. The patient was asymptomatic and returned to his previous level of function and elected not to have the remaining hardware removed. The patient went on to play semi-professional football. **Uniqueness:** Injuries to the tarsometatarsal joint complex represent approximately 0.2% of all fractures. Up to 20% of these injuries are missed on initial radiographic evaluation. Subtle Lisfranc injuries are more commonplace in athletics and may go undiagnosed, however a homolateral Lisfranc dislocation is not frequently seen in the athletic arena because of the force and mechanism required to generate the injury. **Conclusions:** Although rare, this traumatic injury can result from participation in athletic activities. Athletic trainers must be prepared to provide thorough evaluation, emergency care, and post-operative treatment of the injury to promote a satisfactory outcome.

Acute Lateral Ankle Pain in an Intercollegiate Volleyball Player

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Background: A healthy 22 year-old female intercollegiate volleyball player sustained severe right ankle trauma after landing on a teammate's foot. On-site, the patient reported hearing a "crunch" followed by immediate, lateral ankle pain. AT examination identified blood on her sock. The patient was calmed and transported to the sideline. The AT removed the patient's sock and shoe to perform an in-depth examination. A 2"(5 cm) laceration just distal to the right lateral malleolus with oozing blood was visualized. Palpation identified diffuse tenderness over the lateral malleolus with intact neurovascular function **Differential Diagnosis:** fracture, talocrural dislocation, lateral ankle sprain, laceration, and severe open ankle sprain (SOAS). **Treatment:** EMS was activated and the AT applied elevation and compression with sterile gauze to the open wound. Upon EMS arrival, the patient was dressed, splinted, and transported to the emergency department. The patient was seen by the attending physician who ordered IV morphine and lower extremity radiographs which revealed soft tissue swelling, a skin defect over the lateral malleolus, pneumarthrosis around the ankle, and normal anatomical alignment without fracture or dislocation. The patient was referred to an in-house orthopedist who ordered a CT scan which also revealed tissue emphysema within the peroneus brevis, peroneus longus, tibilias posterior, flexor digitorum longus, and flexor halluces longus tendons. The orthopedist then ordered a saline joint integrity test which identified an open and compromised talocrural joint. The patient was definitively diagnosed with a SOAS, admitted, and prepped for surgery. The patient underwent an anterolateral ligamentous repair and talocrural joint irrigation, immobilized with a split cast, and kept for observation. Status post 2 days, the patient was prescribed anticoagulants, antibiotics, non-weight bearing crutch gait pattern, instructed to follow up with her orthopedist, and discharged. Status post 1 week, the patient was seen by the team orthopedist and was removed from the split cast. The patient was recasted in dorsiflexion, instructed to continue with the NWB crutches, and ordered to follow up in a week. Status post 2 weeks, the sutures were removed and the patient was prescribed additional wound closures, a walking boot, and instructed to ambulate utilizing PWB crutch gait pattern for 6 weeks. Status post 2 months, the patient was cleared to begin rehabilitation with the AT. Status post 6 months, the patient was cleared for full activity and was able to perform activities without pain. One month post clearance, the patient graduated from the institution; however, she developed a clicking sensation in her ankle and will follow up with a foot and ankle orthopedic specialist of her choice to evaluate the mechanical irritation. **Uniqueness:** SOAS is a rare diagnosis and accounts for 0.002% of all trauma cases and 0.22% of all ankle trauma cases. SOAS is normally associated with motor vehicle accidents or falls from significant heights, rather than athletic activities. **Conclusions:** SOAS is an extremely rare sports-related injury and defined as a tear of the lateral or medial ankle ligaments with an associated transverse tear of the skin over the corresponding malleolus. Given that the AT was the first healthcare professional on site, it was critical that the AT was proficient in the evaluation and management of acute trauma. Specifically, the ability to carefully and expediently remove the patient's equipment in order to access the injury, select and use the appropriate procedure for managing external hemorrhage, and select and apply appropriate splinting material to immobilize the injured area helped stabilize the patient. Additionally, the use of diagnostic imaging to identify air in the joint and soft tissues led to the diagnosis and intraoperative findings and aided in the surgical intervention to repair the damaged tissues.

Syndesmotic (High Ankle) Sprains in a College Football Athlete

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Background: Ankle injuries are extremely common injuries occurring in athletes with the severity of these injuries vary depending on the ankle complexity and structure. Syndesmotic or high ankle sprains can occur less often, but often require an athlete to experience a longer recovery period. A 20 year-old (185 cm and 104 kg) Division IA football athlete received a high ankle sprain during the third quarter of competition and needed assistance off the field. The mechanism of injury was the athlete's contralaterlateral knee rolling up on the right foot causing the fibula to separate from the tibia in dorsiflexion and external rotation. The athlete was point tender at the anterior tibiofibular ligament and interosseous membrane causing extreme pain with the need to be carted off the field. Initial evaluation and X-ray revealed no bone deformities, but extreme pain on the anterior tibiofibular ligament. Pain was experienced, during active ROM, single leg calf raises, standing Kleiger's test, and dorsiflexion-external rotation during evaluation. The athlete was immobilized in a large boot Aircast with the use of crutches to assist with ambulation. The athlete was advised to report to treatment and follow up the next day of onset. **Differential Diagnosis:** Maisonnueve Fracture, Webber Fracture, Deltoid Ligament Sprain, and Anterior Talofibular Ligament Sprain. **Treatment:** Athlete began treatment with the athletic training staff the following day of onset. The athlete reported to treatments three times a day until further progression following a designed rehabilitation protocol. Athlete was referred to team physician where he underwent further physical evaluation and MRI. MRI revealed a complete syndesmotic sprain tear of the right foot with no bone deformities. A rehabilitation plan with short and long

term goals were established for the athlete. Athlete was treated conservatively with therapeutic exercises, modalities, and prescription medicine. This treatment was designed into four phases that implemented a gradual return to play progression designed by the sports medicine staff and physicians. During the return to play process, the athlete sustained a mild set back during the last phase of his protocol in which he accumulated an extra 13 days of time loss. This set back was sustained on the athletes first full participation practice where vigorous cutting and full contact was presented. The medical staff revised the rehabilitation protocol where the return to play process was then continued based on the athletes ability. **Uniqueness:** Evidence suggested that syndesmosis sprains typically require 6 to 8 weeks of treatment and rehabilitation for recovery. With the athlete receiving a complete anterior tibiofibular ligament rupture, surgery was not obtained due to a longer recovery time. The athlete was able to return to full participation within 43 days with a mild set back during his rehabilitation protocol. The short period of recovery was accumulated due to the thorough rehabilitation protocol and persistent treatments. **Conclusions:** The results of this case report suggested that a complete rupture of the tibiofibular ligament will not lengthen recovery time if surgery is not advised. With advanced rehabilitation equipment and protocols, the athlete was able to return to full participation after 43 days. During the rehabilitation process, the athlete reported 3 times a day where multiple modalities and therapeutic exercises were implemented. With the exception of a 13 day time loss, no other set backs were acquired during the rehabilitation process. This study is a broad explanation of a complex injury and the recovery process from a Division IA athlete and institution that will provide insight for multiple clinicians.

Short-Term Ankle Immobilization Does Not Alter Nervous System Excitability in Uninjured Individuals

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Context: Ankle immobilization devices are frequently implemented after a variety of injuries, including ankle sprain, in order to protect and optimally load the joint. Recent evidence has indicated prolonged casting affects nervous system excitability in uninjured participants. However, no studies have described the effects of clinical devices, such as immobilization boots and pneumatic leg splints, on neurological function. **Objective:** The purpose of this study was to determine the effects of 30 minutes of ambulation in ankle immobilization devices on cortical and reflexive excitability in uninjured participants. **Design:** Crossover study. **Setting:** Biomechanics laboratory. **Patients or Other Participants:** Twelve uninjured participants (22.5 ± 1.4 yrs, 173.05 ± 17.5 cm, 71.6 ± 12.7 kg) volunteered for this study. **Interventions:** Participants reported for testing on 3 days, each 3 to 7 days apart. Baseline measurements of cortical and reflexive excitability were taken prior to and following 30 minutes of ambulation at 1.0m/s on an instrumented treadmill. On each day subjects were assigned, in a randomized order, to ambulate wearing either a pneumatic leg splint (AirCast Air Stirrup, DJO Global, Vista, CA), an ankle immobilizer (AirCast PF Walker Boot, DJO Global, Vista, CA), or walk barefoot. **Main Outcome Measures:** Cortical excitability was assessed through transcranial magnetic stimulation over the primary motor cortex. Electromyography electrodes were placed over the tibialis anterior (TA), peroneus longus (PL) and soleus (SOL) muscles of the test leg. The size of motor evoked potentials at 90, 110, and 150 percent of the resting motor threshold were assessed before and after 30 minutes of ambulation. Reflexive excitability was determined from the ratio of maximum reflexive to direct motor response (Hmax:Mmax) from stimulation to the sciatic nerve in the popliteal fossa. Changes across devices and before and after walking were assessed with factorial analysis of variance ($\alpha = 0.05$). **Results:** Cortical excitability to the lower leg muscles was not observed to change after use of the Aircast (Change = 0.4 ± 66.6%), Boot (Change = 24.5 ± 97.1%), or Barefoot walking (Change = 13.5 ± 66.2%). No significant differences were observed between ankle immobilization devices for cortical excitability (TA: $F = 1.733$, $p = 0.208$, PL: $F = 2.188$, $p = 0.149$, SOL: $F = 0.135$, $p = 0.723$) or reflexive excitability ($F = 0.243$, $p = 0.787$). **Conclusions:** It has been proposed that optimal loading after injury through immobilization may be beneficial for preventing maladaptive neuroplasticity associated with musculoskeletal injury. Although previous evidence has suggested immobilization by casting serves to modify cortical and reflexive excitability in uninjured participants, it appears that the use of clinical devices such as boot immobilizers and pneumatic splints are unable to elicit a similar effect with short-term application. This suggests that neuroplasticity changes after immobilization likely occur through long-term potentiation rather than more short-term forms of synaptic plasticity (post-tetanic potentiation). However, subsequent investigations implementing a long-term immobilization in similar devices among injured participants would be necessary to determine if these devices indeed serve to affect neuroplasticity.

Epidemiology of Secondary School Boys' and Girls' Basketball Injuries: A Report From the National Athletic Treatment, Injury, and Outcomes Network

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Context: Nearly 1 million athletes play secondary school basketball, ranking it one of the most popular team sports. Much is known about time loss (TL) injuries associated with basketball, yet little is known about non-time loss (NTL) injury patterns. Knowledge of NTL injury patterns will assist in creating prevention and management strategies for these injuries. **Objective:** To describe the epidemiology of TL and NTL injuries sustained by boys' and girls' secondary school basketball athletes. **Design:** Descriptive epidemiology. **Setting:** Eighty-six unique schools provided data, with 84 contributing to boys' basketball (146 team-seasons) and 83 for girls' basketball (143 team-seasons). **Patients or Other Participants:** Male and female athletes participating in secondary school-sponsored basketball during the 2011/2012 and 2013/2014 academic years. **Interventions:** Boys' and girls' basketball data from the National Athletic Treatment, Injury, and Outcomes Network (NATION) injury surveillance program from the 2011/2012 through 2013/2014 years were analyzed. Athletic Trainers reported all injuries and exposures. **Main Outcome Measures:** Injury counts, rates, and rate ratios (IRR), were reported with 95% confidence intervals (CI). **Results:** NATION captured a total of 2,652 injuries over 364,355

athlete-exposures (AEs) for boys' basketball and 2,389 injuries over 288,286 AEs for girls' basketball, producing rates of 7.28/1,000AE (95% CI: 7.00, 7.56) for boys and 8.29/1,000AE (95% CI: 7.95, 8.62) for girls. The overall injury rates were similar for boys and girls (IRR: 1.14, 95% CI: 1.08, 1.20). For boys, 558 (21.0%) injuries were TL and 2,094 (79.0%) were NTL, producing a TL injury rate of 1.53/1,000AE (95% CI: 1.40, 1.66) and a NTL injury rate of 5.75/1,000AE (95% CI: 5.50, 5.99). For girls, 494 (20.7%) injuries were TL and 1,895 (79.3%) were NTL, producing a TL injury rate of 1.71/1,000AE (95% CI: 1.56, 1.86) and a NTL injury rate of 6.57/1,000AE (95% CI: 6.28, 6.87). Rates of TL and NTL injuries were similar between boys' and girls' basketball (TL IRR: 1.12, 95% CI: 0.99, 1.26; NTL IRR: 1.14, 95% CI: 1.07,1.22). The most common NTL body locations of injuries in both boys and girls were to the ankle (boys: n = 566, 69.6% NTL; girls: n = 459, 76.7% NTL), hand/wrist (boys: n = 430, 91.2% NTL; girls: n = 416, 92.8% NTL), knee (boys: n = 382, 85.9% NTL; girls: n = 388, 81.4% NTL), and head/face (boys: n = 288, 51.7% NTL; girls: n = 247, 65.2% NTL). The majority of all injuries in boys and girls were sprains/strains (boys: n = 960, 36%; girls: n = 872, 36.5%) and contusions (boys: n = 796, 30%; girls: n = 607, 25.4%), the predominance of which were classified as NTL (boys: sprains/strains n = 74.3%, contusions n = 95.9%; girls: sprains/strains = 79.1%, contusions = 95.7%). **Conclusions:** The rate of injury in boys' and girls' secondary school basketball is high, with the majority of injuries being NTL. Overall, boys' and girls' basketball did not demonstrate large differences in injury rates. Future research aimed at injury prevention strategies is needed.

The Epidemiological Study of Post-Traumatic Ankle Osteoarthritis After Ankle Sprain in the Middle Aged People Using National Health Insurance Sharing Service (NHISS) 450,000 Cohort Data: Prospective Design

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Context: The development of post-traumatic ankle osteoarthritis (OA) has been established as a significant risk after having ankle ligament sprains. However, research on the relationship between ligament injuries and ankle OA in middle aged people is still not studied in depth. **Objective:** The purposes of this study are first to examine the risk of ankle ligament sprains for developing ankle OA in the middle aged and second to figure out whether the sprain directly cause ankle OA. **Design:** Prospective study. **Setting:** 450,000 cohort database from National Health Insurance Sharing Service (NHISS) which offers Korean health insurance information including patient's diagnosis code and their physical indexes. **Patients or Other Participants:** 448,754 randomly sampled cohort group were analyzed. Among them 7667 patients (male= 3,293; female = 4,298, age = 52.7 ± 9.5 years; BMI = 24.3 ± 3 kg/m2) who underwent ankle sprains in year 2002 were prospectively recruited. The remnant 441,163 (male = 228,123; female= 213,040, age = 53.1 ± 9.7 years, BMI = 24 ± 3 kg/m2) population were collected for the controls without ankle sprain. **Interventions:** The patients with ankle sprain diagnostic International Classification of Diseases (ICD) code in 2002 were prospectively traced until 2013 to monitor whether or not they developed ankle OA. To determine whether there were differences of risk depending on time period, we divided the timeline into two subgroups; less than 5 years and more than 5 years from the ankle sprain. **Main Outcome Measures:** Adjusted odds ratios (ORs) and 95% confidential intervals (CIs) were estimated. **Results:** The following odds ratios on each period were significantly associated with ankle degenerative changes. The patients with ankle ligaments injuries were 2.3 times more likely to develop ankle OA than patients without injuries during whole 11 years [2003 - 2013; (OR: 2.29; 95% Cis: 2.12 – 2.50)]. The patients with ankle ligaments injuries were 2.8 times more likely to develop ankle OA than patients without injuries within 5 years [2003 - 2007; (OR: 2.81; 95% Cis: 2.47 - 3.31)]. Likewise, the patients with injuries were 2.1 times more likely to advance to OA than controls during 2008-2013 (OR, 2.10; 95% CIs, 1.91-2.33). **Conclusions:** The ankle sprains were a significant risk factor of the ankle OA throughout the follow-up of the middle aged patients. Furthermore the risk of the OA for the middle aged patients appeared to develop into OA faster in less than 5 years. Therefore, there needs to be an immediate prevention strategies of ankle osteoarthritis in the middle aged people.

Implementation of Automated External Defibrillator Policies in Secondary School Athletics

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Context: Cardiac arrest is the leading cause of death in sports. However, evidence has shown that when an Automated External Defibrillator (AED) is utilized within 1-2 minutes survival rates can be as high as 90%. The National Athletic Trainer's Association's (NATA) has published current evidence-based best practices on AED use recommending proper training, accessibility by trained personnel and sudden cardiac arrest. Yet, the adoption of the AED specific guidelines at the secondary school level is currently unknown. **Objectives:** To determine the extent of state high school athletics associations (SHSAAs) that require AED policies that meets current evidence-based best practice. Additional consideration was given to state legislation if it also enforces these guidelines. **Design:** Descriptive Study. **Setting:** Secondary school athletics. **Patients or Other Participants:** Not applicable. **Data Collection and Analysis:** Eight recommendations for meeting minimum best practices for AEDs were derived from the 2007 consensus statement for AEDs in collegiate and secondary school athletics. An extensive review of SHSAA handbooks, constitutions, bylaws, policies and procedures, SHSAA websites, and enacted state legislation was performed for the academic year 2015-2016 to identify the inclusion of the aforementioned recommendations into mandated policies for the schools governed by the SHSAA. Frequencies were tabulated for each recommendation. These are presented as a representative sample of the United States and District of Columbia. Percent improvement from the 2014-2015 academic year by individual recommendation was also calculated. **Results:** Of the 51 SHSAAs, only 1 state currently meets all eight evidence-based minimum best practices for AEDs in secondary schools. Only 2% of SHAAs comply with the recommendation of having an AED onsite at every sanctioned athletics event. 94% of SHSAAs comply with the recommendation AEDs be used under the advice and consent of a physician by individuals with proper certification. Fifty percent of SHSAA meet the recommendation that all athletic trainers, coaches, administrators, school nurses and physical education teachers have access to an AED on school property and at all school sanctioned events. Furthermore, only 86% of SHSAA's meet the guideline that those individuals be provided with annual training and certification in cardiopulmonary resuscitation (CPR) and AED use. Sixty-six percent of states & DC comply with the recommendation that AED's be used only after an individual has enacted the EMS system. Additionally, 78% of states recommend that AEDs be inspected annually to ensure proper working order. Lastly, no improvement has been demonstrated for individual recommendations since the 2014-2015 academic year. **Conclusions:** Only 1 SHSAA requires their member schools to follow current evidence-based best practices for AEDs. Given reduced cardiac fatalities associated with the implementation of these guidelines, further efforts are needed to have the remaining states fully adopt these policies to potentially avoid any future deaths.

Acute Naproxen Dose on Hydration and Electrolyte Measures During Moderate-Intense Exercise in the Heat

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Context: Non-steroidal anti-inflammatory drugs (NSAIDs) can cause adverse effects (eg, gastrointestinal distress) in exercising individuals. Observational research is conflicting regarding NSAID effects on fluid-electrolyte balance during exercise, and very few controlled laboratory studies have examined potential effects. **Objective:** To determine acute dose effects of a commonly used over the counter NSAID, naproxen, on fluid and electrolyte measures during moderate-intense endurance exercise in a hot or ambient environment. **Design:** Double-blind, randomized and counterbalanced, crossover. **Setting:** Laboratory. **Patients or Other Participants:** Eleven moderately endurance trained volunteers (6 male, 5 female; age = 27.8 + 6.5 years, weight = 79.1 + 17.9 kg, height = 177 + 9.5 cm, VO2max = 41.4 + 5.7 mL/kg). **Interventions:** Participants completed 4 trials: 1) placebo and ambient; 2) placebo and heat; 3) naproxen and ambient; and 4) naproxen and heat. Participants were administered a 24 hour dose (3 capsules) of placebo (cellulose) or naproxen (220 mg naproxen sodium/dose) prior to cycling 90 minutes in either a hot (temperature = 35.7 + 1.3°C, 53.2 + 3.2% humidity) or ambient (temperature = 22.7 + 1.8°C, 52.4 + 5.5% humidity) environment. After exercise, participants rested 3 hours in an ambient environment (23°C, 56% humidity). **Main Outcome Measures:** Hydration (plasma osmolality [Posm], urine osmolality, urine specific gravity, and body mass change), electrolyte (plasma sodium [PNa] and plasma potassium concentration [PK]), and cardiovascular (heart rate and blood pressure) measures were taken pre-, post-, and 3 hours post-cycling. We measured fluid volume (Fvol) during exercise and rest and total urine volume (Uvol). One-way and repeated measures ANOVAs were used to determine differences in dependent variables within and between experimental trials. **Results:** We found no statistically significant differences between experimental trials for hydration, electrolyte, or cardiovascular measures. All participants began data collection euhydrated (mean Posm = 286 + 6.4 mOsm/L) and maintained hydration throughout exercise and rest. Mean aggregate PNa was < 135 mmol/L at pre, post-, and 3 hours post-exercise and did not significantly change over time. Aggregate PK significantly increased pre- to post-exercise (3.9 + 0.4 to 4.2 + 0.4 mmol/L, P = 0.02). Compared to placebo trials, naproxen trials at post-exercise had higher PK, lower PNa, and lower Posm. Similarly, mean Fvol during exercise and total was higher and Uvol was lower in naproxen trials compared to placebo trials. **Conclusions:** A 24 hour naproxen dose did not significantly alter hydration or electrolyte measures during 90 minutes of cycling. The trend for naproxen to increase Fvol and decrease Uvol, Posm, and PNa suggests possible fluid retention, which should concern individuals at risk for hyponatremia or with pre-existing cardiovascular conditions (ie, hypertension).

Walking Gait Asymmetries in Groups of ACL Reconstructed Patients at Sequential Time Frames Post-Surgery

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Context: Chronic knee dysfunction and an elevated risk for knee joint osteoarthritis are long-term consequences of anterior cruciate ligament reconstruction (ACLR). Overtime, adaptations in lower-extremity gait biomechanics may contribute towards accelerated knee joint degeneration; however, there is limited understanding of how gait biomechanics present over the course of time post-surgery. **Objective:** To examine lower-extremity walking gait asymmetries in ACLR patients at sequential times post-surgery versus healthy controls. **Design:** Descriptive Laboratory Study. **Setting:** Laboratory. **Patients or Other Participants:** 56 participants with a history of primary, unilateral ACLR were stratified into 3 groups based on time post-surgery. Early (n = 18): 9-months to 2-years (11 F, 7 M, 21.7 ± 4.1 years, 68.7 ± 15.6 kg, 1.72 ± .12 m, 17.1 ± 5.3 months post-surgery), Mid (n = 20): >2-years to 5-years (16 F, 4 M, 20.5 ± 2.2 years, 68.5 ± 9.9 kg, 1.73 ± .09 m, 39.4 ± 7.7 months post-surgery), Late (n = 19): >5-years to 15-years (12 F, 6 M, 26.7 ± 4.4 years, 69.5 ± 12.7 kg, 1.73 ± .10 m, 102.7 ± 33.0 months post-surgery). 20 healthy, active Controls with no history of lower extremity injury also participated. **Interventions:** 3D camera-based motion analysis was performed on each participant while walking at 1.34 m/s on an instrumented treadmill. **Main Outcome Measures:** Frontal and sagittal knee and hip kinetics and kinematics and vertical ground reaction forces (vGRF) were collected bilaterally on each participant. For each variable, means and 90% confidence

intervals (CI) for each 1% of the gait cycle were plotted for the involved and uninvolved limbs. Regions of the gait cycle (%) where CIs did not overlap for more than 3% of the gait cycle were considered significantly different between limbs. Mean differences and mean effect sizes (ES) & 95% CI were calculated for those regions. **Results:** The Early ACLR group demonstrated greater knee flexion (47-59%, 4.0 ± .1 degrees, ES = 0.86 [.17, 1.54]), lower vGRF's (52-56%, -0.80 ± .24 N/kg, ES = -0.95 [-1.63, -.26]), lower external knee extension moments (46-51%, -.09 ± .004 Nm/kg*m, ES = -0.98 [-1.67, -.28], and lower external knee adduction moments (52-58%, -.08 ± .02 Nm/kg*m, ES = -0.98 [-1.67, -.28]) on the involved limb. The Late ACLR group demonstrated greater external knee adduction moments (16-32%, 0.09 ± .02 Nm/kg*m, ES = 0.87 [.19, 1.56] and greater external hip adduction moments (10-58%, 0.18 ± .03 Nm/kg*m, ES = 1.13 [.43, 1.84]) on the involved limb. There were no significant inter-limb differences in the Mid ACLR group or Control group. **Conclusions:** The Early ACLR group demonstrated lower knee joint loading in the involved limb, suggesting a potential knee loading avoidance strategy. However, the Late ACLR group demonstrated elevated knee and hip joint loading in the frontal plane on the involved limb. These findings suggest that gait strategies may shift over the course of time post-surgery towards greater loading on the involved knee. This shift may be deleterious for long-term knee joint health.

Meaningful Patient Outcomes Reported by College Athletes Fit the ICF Model: A Report on Recovery Following Lower Extremity Injury

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Context: Confirming a universally accepted model under which our patients' outcomes fit is an important step in advancing athletic training practice and research. The International Classification of Functioning, Disability, and Health (ICF) provide a framework and common language for describing and understanding health that incorporates function, disability, as well as contextual factors. The structure of the ICF divides each component into Chapters, which can be further separated into second, third, or fourth level domains. It is uncertain however, if the meaningful patient outcomes, reported by college athletes that have sustained a lower extremity (LE) injury, correspond to the ICF model. **Objective:** Identify if meaningful patient outcomes reported by college athletes, following LE injury, correspond with the ICF classification. **Design:** Qualitative **Setting:** Individual face-to-face semi-structured interview in a University research laboratory. **Patients or Other Participants:** Twenty collegiate athletes (10 males, 10 females; age = 20.1 + 1.8 years; sports = basketball, cross country, football, soccer, softball, track & field, volleyball, wrestling) that were in the final stages of recovery following a LE injury within the past year. The injury required medical attention by a certified athletic trainer or physician and prevented them from competing in their chosen sport. **Data Collection and Analysis:** The interviews allowed the athlete to describe their experiences and the outcomes that were most meaningful to them through the various stages of recovery, with special attention towards the later stages of recovery. Interviews were recorded and transcribed verbatim. Data saturation guided the number of participants. Data were analyzed using the Framework Approach by linking appropriate ICF chapters and second level domains. Trustworthiness of the data was established using member checking and peer review. **Results:** Meaningful outcomes encompassed all components of the ICF; however, the majority of responses linked to the activity and participation component, highlighting daily limitations and restrictions in and outside of sport. The most frequently reported Chapters were: mental functions; pain; neuro-musculoskeletal and movement-related functions; general tasks and demands; mobility; and community, social and civic life. Several other important domains were reported, such as: self-care; domestic life; major life areas; products and technology; and support and relationships. **Conclusions:** It appears that meaningful outcomes, reported by college athletes recovering from LE injury, fit the ICF model. Therefore, it is appropriate for athletic trainers to use the ICF as a foundation in describing a patient's status for this patient population. Future research should identify if patients' outcomes from other athletic training settings fit the ICF model, allowing the model to be applied universally in the profession.

Understanding the Role of Secondary School Nurses and Their Collaboration With Athletic Trainers

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Context: Interprofessional and collaborative practice between secondary school nurses and athletic trainers may improve the quality of care to students and student-athletes. Effective interprofessional collaboration requires a working knowledge of the roles and responsibilities of other providers. **Objective:** To determine secondary school nurses' role in treating musculoskeletal injuries, role in treating student-athletes, general responsibilities, perceptions about athletic trainers, and the extent of their collaboration with athletic trainers in the secondary school setting. **Design:** Qualitative. **Setting:** Individual phone interviews. **Patients or Other Participants:** A manual search of all secondary school websites in Indiana and Illinois was completed to retrieve secondary school nurse emails. A total of 1149 email addresses were collected. Fifty-six secondary school nurses completed the initial demographic survey and interviews were continued until data saturation was achieved (n = 15). **Data Collection and Analysis:** Demographic questions were sent to the email addresses of the secondary school nurses with contact information to schedule interviews. Interviews were conducted via telephone using a semi-structured interview guide. Transcripts were transcribed verbatim. Interviews were coded for major themes using a grounded-theory approach. Themes were determined for trustworthiness through member checking and data saturation guided the number of participants needed. **Results:** All participants who completed both the survey and interview were female and worked in the public school system. The majority of nurses worked at more than one school (40.0%), followed by worked at one school (20.0%), and did not specify (40.0%). The majority of nurses had an athletic trainer hired at their main school of employment (86.7%), while 13.3% did not. The majority of nurses currently had a working relationship with the athletic trainer on a daily basis (40.0%), followed by weekly (20.0%), and on occasion (26.7%), and did not specify (13.3%). Five overarching themes from the interviews were identified regarding secondary school nurses' roles and their collaboration with athletic trainers: Nurse Responsibilities, Shared Responsibilities, Nurse Interprofessional Collaborations, Keys to Positive Working Relationships, and Barriers to Positive Working Relationships. Nurses considered concussion care as a primary area of collaboration between athletic trainers and nurses. Communication and trust were keys for positive working relationships. Shared space and documentation were specific and tangible concepts that could help enhance this relationship between providers. **Conclusions:** Secondary school nurses and athletic trainers have coinciding roles that allow for potential collaboration to occur. There are inherent barriers to collaboration that make it difficult for both professionals to work together, but communication, individual expertise, shared resources, trust, and elimination of financial restrictions should provide for optimal collaboration. Secondary school nurses and athletic trainers should collaborate in order to enhance patient care through their shared roles, especially with concussion care. Education on each other's roles and regular communication is important for collaboration to occur.

Physical Activity Levels and Subjective Function in Individuals With and Without Patellofemoral Pain

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Context: Patellofemoral pain (PFP) is a chronic lower extremity condition that results in long-term subjective and objective impairments. PFP patients have been found to have increased pain with activity that has been suggested to increase a fear avoidance response. PFP has also been identified to result in modification or cessation in activity levels. However, the extent of differences in activity level is unknown in individuals with or without PFP or if a relationship between activity level, pain or fear avoidance exists. **Objective:** Determine differences in subjective function (pain, knee function, and fear avoidance) and activity level between individuals with and without PFP. **Design:** Case-control study. **Setting:** Laboratory **Patients or Other Participants:** 20 participants with PFP (15 females, 5 males; Age = 23.5 ± 1.9 years; Height = 165.7 ± 6.0cm; Mass = 65.5 ± 13.6 kg) and 20 healthy participants with no history of lower extremity injury (15 females, 5 males; Age = 20.6 ± 4.8 years; Height = 169.2 ± 5.3 cm; Mass = 67.7 ± 9.5 kg) participated in the current study. **Interventions:** Participants were provided a Fitbit charge HR and instructed to wear it daily for 14 consecutive days. Steps per day and minutes of mild, moderate and high activity were recorded with the middle 7-days being analyzed. The Anterior Knee Pain Scale (AKPS), worst pain in last 72-hours (WVAS), and Fear Avoidance Belief Questionnaire (FABQ) were also collected. **Main Outcome Measures:** Paired t-tests were used to compare variables of interest between groups. Pearson's r correlation coefficients were used to determine if relationships existed between subjective function and objective activity levels. All analyses were conducted with $\alpha = 0.05$. **Results:** Individuals with PFP took 3,413 less steps per day than their healthy counterparts (PFP: 8,629.7 ± 1,665.3 steps, Healthy: 12,042.2 ± 3,878.7 steps, $p = .004$). PFP patients also completed less minutes of mild activity per day (PFP: 163.3 ± 38.1 minutes, Healthy: 203.7 ± 38.7 minutes, $p = .007$) and high activity per day (PFP: 17.8 ± 7.9 minutes, Healthy: 27.9 ± 12.3 minutes, $p = .012$). Significant correlations were found between steps per day and AKPS ($r = .470$, $p = .002$), WVAS ($r = -.378$, $p = .016$), and FABQ ($r = -.481$, $p = .002$) in the PFP population. No significant correlations were seen in any subjective or objective variables in the healthy population, $p > .05$. No correlations were present between subjective function and minutes of mild, moderate and high activity in either group, $p > .05$. **Conclusions:** PFP patients were significantly less active than healthy individuals in both steps per day and minutes of mild and high activity. This decrease in activity may have negative implications on health related quality of life. Increases in pain and elevated fear avoidance both had a negative relationship with steps per day in patients with PFP. Self-reported knee function did have a positive relationship on activity level in PFP patients. Clinicians should be aware that individuals with PFP present with both subjective and objective impairments that should be considered during evaluation and treatment.

Differences in Quality of Life Among Patients After Knee Surgery

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Context: Knee injury is one of the most common musculoskeletal injuries among physically active individuals. Knee injury leads to a decrease in quality of life (QOL), often characterized by increased pain, decreased physical activity (PA) levels, earlier onset of knee osteoarthritis, functional limitations, and lower scores on traditional objective assessments. While these limitations have been addressed in the literature, long-term outcomes after knee injury have not been documented comprehensively across the lifespan in this patient population. **Objective:** Examine differences in pain, PA, body mass index (BMI) and QOL among patients with and without a history of knee injury and/or surgery. **Design:** Cross-sectional survey. **Setting:** Population-based, online survey. **Patients or Other Participants:** A total of 1,724 adults volunteered to complete a survey about their knee injury and surgery history, PA status, overall pain, and QOL. Of these, 275 sustained a knee injury requiring surgical intervention (SURG; age: 53.8 ± 16.0 years; BMI: 29.89 ± 7.962 kg/m2), 448 knee injuries were managed conservatively (NON; age: 46.0 ± 16.0 years; BMI: 27.50 ± 6.894 kg/m2), and 999 reported no lower body injury (CTRL; age: 44.0 ± 25.2 years; BMI: 26.90 ± 6.549 kg/m2). **Interventions:** An online survey utilized questions about participant demographics, musculoskeletal injury history, QOL, levels of PA, and overall bodily pain. **Main Outcome Measures:** Injury history, surgery history, PA level

(Tegner Activity Scale), overall body pain (numeric pain scale 0-10), BMI, and QOL [SF-8 mental (MCS) and physical component scores (PCS)] were documented. Independent t-tests were utilized to determine differences in QOL and BMI between the control group and knee injury group. Independent samples Kruskal-Wallis tests were used to compare PA and pain scores between the control and knee injury groups. One-way ANOVA tests were utilized to determine differences in QOL and BMI between groups, while independent samples Kruskal-Wallis tests were used to compare PA and pain scores between groups. Significance level was set a priori at $P < 0.05$. **Results:** SURG participants recorded higher pain scores and BMI and lower PA levels and PCS than NON (pain: $P < 0.001$; BMI: $P < 0.001$; PA: $P = 0.15$; PCS: $P < 0.001$) and CTRL (pain: $P < 0.001$; BMI: $P < 0.001$; PA: $P = 0.032$; PCS: $P < 0.001$) groups. Additionally, NON had higher pain ($P = 0.003$) and lower PCS ($P = 0.011$) compared to CTRL. **Conclusions:** Our data supports that individuals with a history of knee injury have poorer health outcomes compared to those that have never sustained an injury. Further, this data suggest that surgical management of knee injuries produced more adverse health effects when compared to non-surgically treated knee injuries. These findings suggest a need for further research to improve health outcomes following knee injury/surgery.

Can the IKDC Subjective Patient Outcome Predict Limb Asymmetries in Clinician Reported Outcomes?

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Context: To safely and accurately return patients to activity, clinicians require use of instrumentation which oftentimes can compromise their clinical time, budget, and work space. Novel measurements have long sought to simplify this by improving measurement efficiency at reduced costs to the clinician and patient. Patient reported outcomes have been demonstrated to correlate to impairment and could potentially avoid each of these clinical barriers while using the patient's feedback to evaluate their function. **Objective:** Determine if the International Knee Documentation Committee Subjective Form (IKDC-SF), a patient reported outcome, could predict limb asymmetries in clinician reported outcomes of lower limb strength, dynamic balance, and function. **Design:** Prospective, cohort. **Setting:** Research laboratory. **Patients or Other Participants:** Thirty-nine (12 males and 27 females) non-injured, active, college-aged participants (23.2 ± 2.9 yrs, 170.2 ± 9.1 cm, 68.4 ± 15.6 kg) volunteered for the study. Interventions: All patients completed separate IKDC-SF questionnaires rating their right and left knee function. Isometric lower limb strength for knee extension, knee flexion, and hip abduction was obtained using a tension-compression load cell was assessed bilaterally. Dynamic balance was assessed in the Anterior (YBT-ANT), Posterolateral (YBT-PL), and Posteromedial (YBT-PM) directions for each leg using the Y-Balance Test (YBT) and a single leg hop (SLH) for distance was performed bilaterally to assess function. **Main Outcome Measures:** Limb symmetry index (LSI) scores were calculated for each variable and data for each participant was dichotomized into groups of normal and abnormal symmetry for each variable. The IKDC-SF data was dichotomized using the minimal detectable change score for the form while the measures of limb symmetry were dichotomized using published, clinically acceptable scores for each measure. A Receiver Operating Curve (ROC) was plotted for each variable to determine the ability of the IKDC to predict asymmetries in each clinician reported outcome measure. **Results:** The ROC Curve analysis produced poor ability (Area Under Curve, AUC, < 0.70) to predict asymmetries in all of the clinician reported outcome measures with the exception of the YBT-PL reach direction (AUC = 0.78). For this measure the IKDC-SF demonstrated a sensitivity of 0.75 and specificity of 0.51 to detect a LSI difference greater than 4 cm. **Conclusions:** Although the IKDC-SF is an excellent subjective patient evaluation tool for clinical practice, it had a poor ability to detect clinically relevant clinician reported limb asymmetries in a healthy sample of active individuals and should not be used for this purpose. Because the form has demonstrated the ability to measure function, there may be utility in using this in individuals recovering from an injury and the link to limb symmetry should be investigated in that population.

Effect of Response Shift on Agreement Between Patient Reported Outcomes and Performance-Based Measures in Knee Patients

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Context: Patient reported outcome measures (PROs) are survey instruments that are used to assess the patient's perspective on the status of their injury. Patients routinely underestimate or overestimate their abilities to perform functional tasks on these instruments. Additionally, performance-based measures (PBMs) are used to examine the patient's ability to perform functional tasks relative to the involved pathology. Anecdotally, it has been observed that PRO scores were more correlated with PBMs if PROs were completed after the PBMs were assessed. It is theorized that PBMs may provide a frame of reference for the patients to use when completing the PROs. This change may result in what is known as a response shift and assist in increasing correlation between PROs and PBMs. However, to our knowledge no randomized controlled trials have directly tested this theory. **Objective:** To determine whether the implementation of PBMs prior to the completion of PROs would create a change, or a response shift, in participants' PRO responses. **Design:** Single-Blinded, Randomized controlled trial **Setting:** Sports Medicine Clinic, Physical Therapy Clinic, and Research Laboratory. **Patients or Other Participants:** 16 participants (age = 21.4 ± 3.2 height = 174 cm ± 11 cm, mass = 78 kg ± 17 kg) who had been removed from physical activity for a minimum of 1-week due to a knee injury volunteered. Additional inclusion criteria were ≥5 on the Tegner Physical Activity Assessment, and >46 on the International Knee Documentation Committee Subjective Knee Evaluation Form (IKDC). **Interventions:** Participants were randomly assigned to an intervention or control group. The intervention group (n = 8) completed the following PBMs: single-leg hop for distance, crossover hop for distance, anterior reach of the SEBT, 30-second maximal step-down task, and the compact agility test. The control group(n=8) watched instructional videos from the FIFA11+ injury prevention program. All subjects completed the IKDC and the Knee Injury and Osteoarthritis Outcome Score Recreational and Sports Subscale (KOOSsport) both pre and post intervention. **Main Outcome Measures:** The independent variable was group (PBMs or FIFA11+). The dependent variables included PRO absolute change scores (|PROpost-PROpre|) and PRO raw change scores (PROpost-PROpre). Independent t-tests were used to examine differences in raw change scores and absolute change scores between groups. **Results:** There were no group differences in IKDC Absolute (PBM = 2.73 ± 3.41, FIFA11 += 1.44 ± 1.34; p = 0.34) or IKDC Raw (PBM = -2.15 ± 3.86, FIFA11 += 0.58 ± 1.94; p = 0.096). Additionally, there were no group differences in KOOSsport-Absolute (PBM = 3.75 ± 3.54, FIFA11 += 1.88 ± 3.72; p = 0.32) or KOOSsport-Raw (PBM = 0.00 ± 5.35, FIFA11 += -0.63 ± 4.17; p = 0.80). Additionally, the scores did not meet or approach MCID values. **Conclusions:** No significant differences between groups were noted in this study. Instead of providing a frame of reference for the patient, PBMs may evaluate a different aspect of health outcomes than PROs. It appears that PRO scores are not significantly influenced by testing order and may be completed before or after PBMs without affecting clinical interpretation.

Perceptions of Race and Ethnic Diversity on Athletic Training Clinical Practice

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Context: The National Athletic Trainers' Association (NATA) membership statistics currently show a 14.9% ethnically diverse population, which is stark in comparison to the white/non-Hispanic population of 80.8%. However, it is a substantial increase from only 8.3% in 1999. With the increase in the ethnically diverse membership population, it is important to understand how an ethnic background influences the development of the athletic trainer. **Objective:** Understand the experiences of ethnically diverse athletic trainers and how their ethnic background has impacted them as athletic trainers. **Design:** General inductive. **Setting:** NATA Practice Settings. **Patients or Other Participants:** 18 racially and ethnically diverse athletic trainers employed in a variety of settings, 8 male, 10 female. Participants were recruited due to their ethnicity, which included African-American (n = 9), Hispanic (n = 6), Asian (n = 1), and Multi-Racial (n-2). Our participants average age was XX with 11 average years of experience (±11, .75-40). The participants represented a variety of job settings, including a position in Higher Education (n = 5), College/University (n = 5), Clinic (n = 3), Secondary School (n = 2), Professional Sports (n = 2), Other (n = 2). **Data Collection and Analysis:** Participants were purposively chosen from the data set that responded to a structured survey as part of a EDAC funded Anthology project, which asked questions about race and ethnic diversity in athletic training. All participants were given the choice to journal responses through a Qualtrics survey, submit a video message, or schedule a video call with a researcher answering a set of structured, pre-determined questions related to their experiences with only video responses used for this study. Data was analyzed following general inductive analysis procedures. Trustworthiness was established through the use of multiple analyst triangulations and peer review. **Results:** Analysis revealed 3 themes: open-mindedness, connections, and mentorship. Open-mindedness was perceived to be an aspect of their clinical practice attributed to their race and ethnicity that gave them a better ability to understand the athlete as a whole, elevating the level of care provided to their athletes. Participants also referred to their cultural background as a reason why they are able to connect with and develop relationships with their athletes due to familiarity and a sense of inclusion. The theme of mentorship stems from participants identifying with fellow racially diverse members and acting as a resource for minority athletes. **Conclusions:** Diverse athletic trainers identified that their racial and ethnic backgrounds had a positive impact on their ability to connect with and relate to their patients and athletes. These athletic trainers believe that their ethnicity and race give them an appreciation for all athletes; they consider themselves able to accept the individualities of their patients and student athletes more readily than non-ethnically diverse athletic trainers. As the ethnically diverse population in athletic training continues to grow, future research should be done to promote minorities in the athletic training profession and expose minority high school students to the profession.

The Experiences of Women Athletic Trainers Providing Medical Care to Male Sports Teams

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Context: The membership statistics of the National Athletic Trainers' Association currently show a similar distribution of men (45.35%) and women (54.49%). In theory, men and women should have equal opportunity to work with male sports teams. Though membership numbers are comparable, there are very few women athletic trainers providing medical care to male sports teams at the professional or college level. Women in athletic training face a barrier to working with male sports; the reasons are multi-factorial including traditional sex stereotyping and the social networking of male leaders (i.e. the "old boys club"). The manifestation of these stereotypes in college athletics may be due to traditional female gender roles. **Objective:** To explore the experiences of women athletic trainers providing medical care to a male athletic team within the collegiate setting. **Design:** Phenomenology **Setting:** NCAA Division 1 **Patients or Other Participants:** 15 female athletic trainers in the NCAA Division I setting who were providing medical care to a male sport team. Participants' average age was 33 years old (±9, 23-58) with 11 average years of experience (±9, 2-35) as an athletic trainer. Primary sport coverage varied, 6 women covered only a single sport, 9 identified covering multiple sports. **Data Collection and Analysis:** One on one telephone interviews were completed, recorded and transcribed. Interview questions were open-ended to gain a holistic impression of each woman's experience. Demographic information and self-reported characteristics attributed to personality based upon gender roles were also collected.

Data was analyzed using the general inductive approach. Trustworthiness was established through peer review, pilot testing, and multiple analyst triangulation **Results:** Analysis revealed 3 themes. Participants: 1.) encountered mostly positive experiences with student-athletes and coaches, 2.) described being associated with role of "Team Mom", 3.) experienced discriminatory behavior, sexism and gender bias. Though their relationships with student-athletes and coaches were often harmonious, participants experienced sexism and discrimination throughout their careers. Participants struggled to receive comparable treatment to male athletic trainers and identified situations where a "double standard" exists (ie: women had to work harder or act differently than their male counterparts to be perceived analogously). **Conclusions:** Women athletic trainers identified frustrations with being categorized by gender stereotypes. Though their relationships with student-athletes and coaches were positive, the women still experience sexism related to the culture in the workplace. They reported facing a "double standard" from their time as students through their professional careers. Educating coaches, student-athletes and administrators on diversity, developing women's leadership initiatives, and mentorship of young professionals can help to defend against acts of gender bias and sexism. Additionally, rather than accepting the status quo, women can combat gender bias and initiate change by overtly identifying unjust practices.

Providing Medical Care to Male Sports Teams: Attractors to Employment for Female Athletic Trainers

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Context: Female athletic trainers can face barriers to employment within the athletic training profession. Only a quarter of all full-time athletic training positions in the Division I collegiate setting are filled by females, and even fewer hold leadership positions at their universities. Although there is evidence of an increasing percentage of women in athletic training, a small number have been able to break the barrier of working with male sports teams, particularly among collegiate and professional sport settings. **Objective:** Investigate experiences of female athletic trainers seeking employment with male sport teams within the Division I setting. Secondarily, examine factors that attract and motivate female athletic trainers to work with male sports teams. **Design:** Phenomenological qualitative study. **Setting:** National Collegiate Athletic Association (NCAA) Division I. **Patients or Other Participants:** A total of 15 NCAA Division I female athletic trainers providing medical care to male sports teams completed our study. Participants' mean age was 33 (± 9, range = 23-58) years, with 11 (± 9, range = 2-35) years of overall clinical experience, and have been working in their current role for an average of 7 (± 8, range = 2-33) years. **Data Collection and Analysis:** Participants completed semi-structured one-on-one telephone interviews, which were recorded and transcribed. Interview data was analyzed through thematic analysis using a phenomenological approach. Researchers ensured trustworthiness through the use of member credibility checks, peer review, and researcher triangulation. **Results:** Factors that played a role in females gaining employment with male sports teams included 1) pre-existing professional relationships, 2) prior experience with a male sport, and 3) perseverance. A majority of participants identified prior experience and familiarity with members of the sports medicine team as catalysts to obtaining their position. Only four female athletic trainers in our sample were hired directly to their current positions through traditional application procedures. Participants were attracted to their current positions for two primary reasons. The first attractor was environment and competition level of the Division I collegiate setting in its entirety, not just the sport itself. The second attractor was the location of the university. The reasons female athletic trainers pursue positions with male sports teams are multifactorial. **Conclusions:** Due to their positive previous job performance and networking strategies, participants in our sample did not encounter significant obstacles in gaining access to their current positions. Rather, their access was primarily based on hiring practices, job attractors, and the athletic trainer's level of preparation. Our participants spoke about the importance of networking, being committed to their goals and being confident in their clinical skill sets. Embodying and enacting such skills and traits may assist other female athletic trainers hoping to provide medical care to male sports teams at the NCAA Division 1 level.

Athletic Trainers' Perception and Self-Perceived Competence Working With Athletes With Disabilities

Aurelien EP, Pagnotta KD, Mansell JL: Temple University, Philadelphia, PA

Context: There is little research on athletic trainers' (ATs') perceptions and self-perceived competence of working with special populations. In a previous study, ATs had positive feelings regarding working with Special Olympic athletes, but did not feel confident nor competent to properly assist them. Special Olympics athletes are individuals with an intellectual disability, cognitive delay, or development disability. Athletes with disabilities includes individuals with impairments such as: impaired muscle power, limb deficiency, hypertonia, athetosis, visual impairment, etc. To date, no research has been conducted to specifically address ATs perceptions and self-perceived competence working with athletes with disabilities. **Objective:** The purpose of this study is to identify certified ATs' level of comfort, and perceptions working with athletes with disabilities; as well as ATs' self-perceived competence working with the disabled athlete population. **Design:** Inductive content analysis based in the grounded theory. **Setting:** Qualitative study using an online survey and semi-structured phone interviews. **Patients or Other Participants:** Participants were recruited via convenience and snowball sampling. Participant recruitment and data analysis ceased when data saturation was reached. In total 10 ATs participated in the initial online questionnaire. 3 participated in the follow-up phone interview. **Data Collection and Analysis:** Data was collected using Qualtrics software. Participants who volunteered for a follow up interview participated in a semi-structured interview that was recorded and transcribed verbatim. Two researchers separately analyzed the data using a general inductive approach and met to confirm findings. A combination of Likert and open-ended questions was used to triangulate the data. Additionally, the follow-up interviews were used to triangulate the data. Finally, a peer reviewer not involved in the data collection analyzed the questions and results to ensure accuracy and to prevent bias. **Results:** Three major themes emerged regarding athletic trainers' perceptions and self-perceived competence working with athletes with disabilities: 1) education, 2) intellectual disabilities, 3) incorrect definition. The education theme included two lower themes: ATs had minimal to no education working with the population and ATs did not understand the role of other health care providers in providing care to athletes with disabilities. The intellectual disabilities theme had two lower level themes: a) general nervousness/uneasiness working with this group of athletes specifically b) perceived difficulty communicating. Finally, there appears to be confusion amongst ATs on what qualifies as an athlete with a disability. **Conclusions:** ATs' mostly have positive perceptions of athletes with disabilities, but were apprehensive about working with athletes with intellectual disabilities. As health care providers, ATs' did not receive enough formal education to work with this population and confused athletes with disabilities with Special Olympic athletes. Additional education and preparedness may be necessary as schools and organizations move towards sponsoring and integrating adapted sport.

Clinical Integration: How Minority Athletic Training Students Compare to Nonminority Students

Ensign KE, Hinton K, Powers J, Grove C: Ohio University, Athens, OH; Indiana State University, Terre Haute, IN; Indiana University, Bloomington, IN

Context: Minorities are underrepresented in the athletic training profession. It is important educators understand what factors may be causing this. One area to investigate is how minority students perceive their clinical integration compared to nonminority students. **Objective:** To examine the perception of clinical integration for minority and nonminority athletic training students. **Design:** cross-sectional **Setting:** Online Survey **Patients or Other Participants:** Students enrolled in professional athletic training programs in the United States. 577 students, about 4% of student population (422 women and 155 men; age 21.25 ± 2.68), completed the survey. The racial breakdown was 81.5% White, 6.2% Black, 4.7% Hispanic, 2.3% Asian, 0.2 Alaskan Native/Native American, 4.3% Multiracial, 0.9% Other. **Interventions:** Program directors were emailed the survey and asked to forward the email to their students. Students completed a modified version of the Athletic Training Education Program Student Retention Questionnaire (ATEPSRQ) and answered various demographic questions. The ATEPSRQ consists of five subscales: anticipatory factor, academic integration, social integration, clinical integration, and motivation scored on a likert scale of 1 to 5 (1 = strongly disagree; 5 = strongly agree). **Main Outcome Measures:** Dependent variables were the clinical integration subscale and its items. Independent variable was minority status. Using an ANCOVA, clinical integration subscale was compared between minority and nonminority students. Using a MANCOVA, responses on the clinical integration items were compared

between minority and nonminority status with follow up ANOVA's if the overall MANCOVA was significant. Covariates were age, gender, athletic training program admission GPA, and whether students received a Pell grant. Alpha level was set a priori at $p < 0.05$ for all analyses. **Results:** Significant difference between minority students (3.54 ± .32) and nonminority students (3.67 ± .33) on the Clinical Integration Subscale ($F(1,579) = 12.87$, $p \leq .001$; Wilks' $\Lambda = .978$; partial $\eta 2 = .022$). The overall MANCOVA was significant ($p < 0.05$). Significant difference between minority students (1.76 ± .70) and nonminority students (1.60 ± .63) on the statement "I am able to learn a great deal at my clinical experiences" ($F(1,579) = 2.249$, $p = .021$; Wilks' Λ=.942; partial $\eta 2 = .058$), between minority students (4.03 ± .81) and nonminority students (4.23 ± .63) on the statement "Overall, I am satisfied with my clinical experiences" ($F(1,579) = 2.249$, $p = .004$; Wilks' $\Lambda = .942$; partial $\eta 2 = .014$), and between minority students (3.09 ± 1.12) and nonminority students (2.79 ± 1.09) on the statement "There are times when I experience a feeling of 'too many hours' at my clinical sites" ($F(1,579) = 6.138$, $p = .025$; Wilks' $\Lambda = .942$; partial $\eta 2 = .009$). **Conclusions:** Minority students reported less clinical integration than nonminority students. Both minority and nonminority students reported low scores for the ability to learn a great deal at their clinical experiences but nonminority students felt their learning opportunities were better. Minority students felt they were spending too much time at their clinical sites compared to nonminority students. It is important to note that though scores were statistically different, they were not different by a large amount.

Free Communications, Oral Presentations: Emergency Management of the Broken Heart

Wednesday, June 28, 2017, 7:00AM-8:15AM, Room 361; Moderator: Yuri Hosokawa, PhD, ATC

Division I Men's Soccer Player With History of a Cardiac Condition: A Case Report

Wesche AJ, Joseph CJ: University of Central Florida, Orlando, FL

Background: The patient was born (1998) with Tetralogy of Fallot (ToF). The 4 defects associated with this congenital heart defect are: a ventricular septal defect, pulmonary stenosis, right ventricular hypertrophy, and an overriding aorta. The patient had this repaired at 5 months of age. At the age of 4 (2002) there was clinical concern about the worsening of his left pulmonary artery (LPA) stenosis. A complete catheterization of the heart was performed and a stent was placed in the LPA. The patient then had a cardiac catheterization and bilateral pulmonary artery angioplasty in 2010. He participated in club sports after this without issue. In 2015 the patient experienced abnormal shortness of breath and an elevated heart rate with participation. A cardiac MRI showed that his right ventricular ejection fraction increased after his procedure in 2010, but there was a stenosis of the LPA and the blood flow to the left lung was reduced. At that time his cardiologist recommended that he have another cardiac catheterization and a larger stent placed in the LPA to increase blood flow to the left lung. The patient ignored the recommendation and continued to participate in club soccer with his symptoms until he arrived on campus in July of 2016. **Differential Diagnosis:** Tetralogy of Fallot. **Treatment:** During pre-participation physicals he underwent an EKG, echocardiogram, and stress echocardiogram. The stress echocardiogram was within normal limits, but due to of the patient's history of LPA stenosis, an MRI of the heart was ordered. The results of the MRI revealed moderate to severe dilation of the right ventricle, LPA stenosis narrowed to 7.7 mm in diameter with mild poststenotic dilation, 27% of pulmonary blood flow via the left pulmonary valve, mild stenosis and moderate regurgitation of the pulmonary valve, mild dilation of the left ventricle, mild dilation of the aortic root, mild tricuspid and mitral regurgitation, and mild dilation of the right atrium. Given the results of the MRI, the team cardiologist did not clear him to participate. He also recommended that the patient have a LPA stent placed, as recommended by the patient's previous physician. The team cardiologist would be willing to reconsider clearing this patient to participate if the results of the procedure returned the patient to an acceptable range for high level athletics. This athlete recently had the LPA stent procedure. During which his current stent was dislodged, causing cardiac arrest. This forced an open heart procedure to remove the old stent and place the new one. He is currently home and recovering. **Uniqueness:** This congenital heart defect occurs in 1 in 2000 people born today. Until recent years, those with ToF have not had a long life expectancy due to subsequent cardiac complications. Those who have ToF repaired often have numerous procedures over the span of their life to correct subsequent cardiac issues, such as pulmonary artery stenosis, valve regurgitation, arrhythmias, and right ventricular aneurysm. Very few athletes reach high levels of participation with this congenital heart condition due to the decreased cardiovascular capacity. The cardiovascular capacity required for collegiate soccer is greater than most sport activities. **Conclusions:** ToF is not an immediate disqualifier for high level athletics but the proper precautions must be taken to ensure a patient's safety. A thorough medical history and cardiac screening are a necessity for those who compete in high level athletics. The failure to be diligent in the pre-participation evaluations can put athletes at risk for serious injury or death.

An Examination of Emergency Planning of Secondary School Athletics Programs in District 4 of the National Athletic Trainers' Association

Popp JK, Berry DC: Ball State University, Muncie, IN; Saginaw Valley State University, University Center, MI

Context: In 2002, the National Athletic Trainers' Association (NATA) issued a position statement regarding emergency planning in athletics, outlining critical components for inclusion in an institution's emergency action plan (EAP). Despite these guidelines, there is little research on the prevalence and quality of EAPs in secondary schools athletics programs. **Objective:** Identify the number of secondary schools within NATA District 4 that have EAPs, and ascertain the quality of the EAP based on its components. **Design:** Cross-sectional study. **Setting:** Online survey. **Patients or Other Participants:** A sample of 1288 athletic trainers (ATs) employed in secondary schools in NATA District 4 received a link to the online survey. A total of 318 ATs (males = 121, females = 197; age = 34.22 + 10.66; years of experience in secondary school = 9.29 + 9.40) completed the survey for a response rate of 24.7%. **Interventions:** The Qualtrics online survey consisted of three sections: demographics, EAP components, and emergency equipment available. The survey was validated for content by a panel of experts. Reliability of this type of survey is not warranted. Participants received an email outlining the study purpose and a survey link. Reminder emails were sent at 2-weeks and 4-weeks. **Main Outcome Measures:** When ATs confirmed the presence of an established EAP, frequencies were collected related to the specific components (e.g. accessibility at each venue, communication mechanism) of the EAP. Pearson chi-square testing determined associations

between having an EAP and other variables (e.g. employment status, school size). Alpha level was set a priori at P < .05. **Results:** 87.7% of ATs indicated their school has an EAP, and 92.0% reported the EAP applies to a broad range of emergencies. While 88.9% of ATs developed the EAP in consultation with school administrators, only 47.1% consulted the team physician and only 39.1% consulted local emergency medical services. Even though 88.5% reported the EAP is specific to each athletic venue, only 41.8% indicated that the EAP is accessible at each venue. 78.5% of ATs reviewed the EAP annually, but merely 41.2% of ATs rehearsed it annually. Just 34.6% of ATs indicated the EAP has been reviewed by legal counsel of the institution. Schools that employ anything other than a full-time AT were less likely to have an EAP (OR .32, 95% CI, 0.12-0.83; P < .05). Schools who employ ATs who also serve as preceptors were more likely to have an EAP (OR 4.16, 95% CI, 1.33-13.01; P < .05). 100% of ATs reported the availability of automated external defibrillators at their institution. **Conclusions:** The large majority of secondary schools in District 4 have an EAP; however, many components are missing. Improvement is needed in the area of emergency planning in secondary school athletics programs. ATs should evaluate their school's EAP and facilitate changes to ensure the minimum professional standards are being met.

Evaluation of College Students Performing Compression-Only Cardiopulmonary Resuscitation with High-Fidelity Equipment

Lyman KJ, Landin KD, Guggisberg R: North Dakota State University, Fargo, ND; Fargo Fire Department, Fargo, ND

Context: There are nearly 350,000 cardiac emergencies every year with the mortality rate estimated at 90%. Effective compression-only cardiopulmonary resuscitation (CPR) has been proven to increase the chance of survival. Research has suggested CPR performance is ineffective by lay public and health care professionals even after certification. **Objective:** The goal of the research was to compare the quality of compression-only CPR among students who declared majors in allied health care professions (e.g. athletic training) and were currently certified in CPR to students who identified as non-allied health care majors (e.g., education). **Design:** Randomized controlled trial **Setting:** Research laboratory. **Patients or Other Participants:** Sixty participants (29 females, 31 males, mean age = 21.8 ± 3.4) were recruited via campus email. Twenty participants with declared majors in allied health care professions and were certified in CPR and 40 participants with declared majors outside of allied health care professions and not CPR certified. **Interventions:** Participants were divided into three groups: (1) 20, declared allied health care students. And 40 non-allied health care students randomized into two groups of 20: (2) non-allied health, no intervention, (3) non-allied health students who were taught compression-only CPR via a 2-minute video and received feedback as they practiced compressions on the high-fidelity manikin (Resusci Anne QCPR). Regardless of group, participants performed 2 minutes of compression-only CPR while quality of compressions was assessed using the Resusci Anne Wireless SkillReporter (Laerdal Ver 2.0.0.14). Assessment included the following aspects of compressions: overall score, mean rate, mean depth, % compressions fully released, and % compressions with appropriate depths. Data were analyzed using a MANOVA to compare differences of compressions between groups. **Main Outcome Measures:** Dependent variables were compression aspects affected by groups. **Results:** The omnibus MANOVA was significant, Wilks' Lambda = .006, F (5, 53) = 999.660 P < 0.001. Univariate tests showed overall score mean differences between groups were significant [F (2, 57) = 32.645, P < 0.001]. Tukey post hoc adjustments were applied; examining between group differences for overall score. Mean differences (MD) between groups are as follows: Groups 1 and 2 (MD = .268, P = 0.006), Groups 1 and 3 (MD = .3995, P < 0.001), Groups 2 and 3 (MD = .6675 P < 0.001). **Conclusions:** Students associated with non-allied health care professions who received visual feedback regarding their performance on compression-only CPR (Group 3), performed better than those who were currently CPR certified and identified as future allied health care professionals (Group 1). Thus, students in health care programs should train with high-fidelity equipment to ensure proper compressions are being conducted.

Skill of Athletic Trainers Performing Two Rescuer CPR

Cashin M, Kearn R, Ratigan N, Stoltz K, Boergers R: Seton Hall University, South Orange, NJ

Context: During acute cardiac emergencies, it is imperative to have trained personnel who are skilled at performing cardiopulmonary resuscitation (CPR) to facilitate a positive patient outcome. CPR skill decay has been documented in numerous healthcare professionals. As part of a pre-test for a broader study we analyzed skill of athletic trainers in performing 2 rescuer CPR. **Objective:** To determine the skill level of athletic trainers performing 2 rescuer CPR on a high fidelity manikin. **Design:** Descriptive Study **Setting:** Simulation Lab **Patients or Other Participants:** Thirty-six (12 males and 24 females) athletic trainers completed this study (Age = Males: 33.3 ± 9.7 years, Females 33.4 ± 9.8 years; AT experience = 10.80 ± 9.01 years). The participants were randomly assigned a partner. **Interventions:** Participant pairs performed two minutes of 2 person CPR on a Q-CPR manikin with SimPad Skill Reporter (Laerdal Medical Corporation, Wappingers Falls, NY) in both the role of the compressor and the ventilator, separately. All ventilations were delivered using a standard pocket mask airway. The SimPad Skill Reporter measured multiple variables related to CPR skill. The CPR score provided by the SimPad is calculated using an algorithm that takes into account incorrect compression depth, incorrect compression rate, incomplete release, inaccurate hand placement, flow time fraction, incorrect ventilation volume and incorrect ventilation rate (based on the American Heart Association 2015 guidelines). Participants were required to achieve an overall score of ≥80% to be deemed proficient or were required to remediate. **Main Outcome Measures:** The dependent variables were overall CPR score (%), compression score (%), ventilation score (%), ventilation volume (mL), ventilation rate (#/min), compression depth (mm), and compression rate (#/min). Descriptive statistics (frequencies, means, standard deviations) were used to describe CPR skill. **Results:** Fourteen of eighteen pairs (77.78%) did not achieve an overall CPR score of 80% on the first attempt. There was a total of 19 trials where participant pairs failed to demonstrate CPR proficiency (≥80%). For the 19 failed trials the overall CPR score was (51.52 ± 19.63%), compression score was (47.58 ± 34.95%), ventilation score was (90.47 ± 13.70%). The 19 failed trials had compression depth (46.32 ± 11.48 mm), compression rate (123.95 ± 12.31/min), ventilation volume (519.42 ± 235.89 mL), and ventilation rate (5.16 ± 1.21/min). **Conclusions:** A large percentage of participant pairs lacked proficiency while performing 2 person CPR indicating that athletic trainers experience skill decay from time of last certification similar to other health care providers. Our data indicates that shallow chest compression depth and faster compression rate were the variables of CPR skill that most attributed to the lack of proficiency in the failed trials. Performing CPR recertification with high fidelity manikins may provide the participant with specific feedback regarding his/her deficiencies so they can make corrections.

The Ability to Provide Quality Chest Compressions Over Lacrosse Shoulder Pads to Initiate CPR

Bowman TG, Boergers RJ, Lininger MR, Cashin MC, Ratigan NC: Lynchburg College, Lynchburg, VA; Seton Hall University, South Orange, NJ; Northern Arizona University, Flagstaff, AZ

Context: Early initiation of Cardiopulmonary Resuscitation (CPR) is essential for improving patient outcomes and decreasing mortality during sudden cardiac arrest. Performance of compressions over football shoulder pads inhibits chest compression depth but speeds time of first compression. Lacrosse equipment has not been studied. **Objective:** To assess the impact of lacrosse shoulder pads on the ability to provide quality chest compressions to simulation manikins. **Design:** Crossover study. **Setting:** Simulation laboratory. **Patients or Other Participants:** Thirty-six (12 Males: 33.3 ± 9.7 years old; 24 females: 33.4 ± 9.8 years old) athletic trainers with current professional rescuer level CPR (26 American Heart Association; 10 American Red Cross) participated. **Interventions:** We used the Resusci Anne Q-CPR manikin (Laerdal Medical Corporation, Wappingers Falls, NY) for all trials. Shoulder pad condition (NSP = no shoulder pads, WBH = Warrior Burn Hitman shoulder pads [Warrior Inc., Boston, MA], STX = STX Cell II shoulder pads [STX LLC, Baltimore, MD]) served as the independent variable. Half (18) of participants performed 3 trials each of NSP and WBH, and the other half did 3 trials each of NSP and STX. All sessions were counterbalanced. **Main Outcome Measures:** We performed three separate, 1-way analyses of variance (ANOVA) for chest compression depth (mm), compression rate (compressions/minute), and ratings of perceived exertion (RPE) with Bonferroni post-hoc analyses. Hand placement accuracy, chest wall recoil, and percentage of compressions

reaching adequate depth were variables expressed as percentages and therefore non-parametric analyses (Kruskal-Wallis tests with Mann-Whitney U for post hoc testing) were utilized to determine differences. **Results:** There was a significant difference between shoulder pad conditions on mean compression depth ($F_{2,213} = 3.73$, $P = .026$, $\omega 2 = .03$) with a significantly shallower depth for the WBH (54.1 ± 5.8) when compared to NSP (56.8 ± 5.7; $P = .021$). For mean compression rate, there was not a significant difference between the shoulder pad conditions ($F_{2,213} = 0.87$, $P = .422$, $\omega 2 = .001$, $1\text{-}\beta = .20$). There was a significant difference in RPE scores ($F_{2,213} = 16.41$, $P < .0001$, $\omega 2 = .12$) depending on shoulder pad condition. Compressions were more difficult with the STX in place (4.1 ± 1.3) compared to NSP (2.9 ± 1.2; $P < .0001$) as well as WBH (3.3 ± 1.1; $P = .002$). There was a significant difference in hand placement accuracy ($\chi^2_2 = 11.14$, $P = .004$) between the three different shoulder pad conditions with NSP having higher percentages than STX ($P = .002$) and STX higher than WBH ($P = .001$). There were no significant differences between shoulder pad conditions for chest wall recoil ($\chi^2_2 = 1.11$, $P = .571$) and percentage of compressions reaching adequate depth ($\chi^2_2 = 5.10$, $P = .078$). **Conclusions:** Based on our results, it may not be necessary to remove lacrosse shoulder pads before initiating chest compressions. Our participants were able to provide high quality chest compressions over two different pairs of shoulder pads by obtaining a depth of 50 mm. Delaying chest compressions to remove lacrosse shoulder pads may be detrimental to patient care.

Free Communications, Oral Presentations: Faculty Development and Transition to Higher Education

Wednesday, June 28, 2017, 8:30AM-9:30AM, Room 361; Moderator: Jeff Konin, PhD, ATC, FNATA

Perceptions of Tenure and Promotion Guidelines and Criteria Among Athletic Training Doctoral Students

Klossner J, Mazerolle SM, Bowman TG: University of Maryland, College Park, MD; University of Connecticut, Storrs, CT; Lynchburg College, Lynchburg, VA

Context: Evidence suggests that athletic training doctoral candidates are socialized through a variety of formal and informal experiences to prepare them for roles in higher education. It is unclear, however, if they are aware of the expectations associated with tenure and/or promotion; a necessary aspect to their formal training for transition into higher education. Tenure is a long-standing tradition among institutions of higher education, but it can often be viewed as a challenge for those faculty members in health-related fields, including athletic training due to multiple competing roles. **Objective:** To investigate the perceptions of athletic training doctoral students concerning the tenure and promotion process. **Design:** Qualitative study. **Setting:** Universities sponsoring doctoral education. **Patients or Other Participants:** Following criterion-sampling procedures, we purposively recruited athletic training doctoral students who were employed through graduate assistantships as they completed their doctoral education. Twenty-four students (16 = females, 8 = males, average age = 28 ± 3 years) participated. Participants represented 9 different institutions, with a majority of them (n = 19) completing their doctoral education at R1 universities as classified by the Carnegie Classification, and the others within R2 universities. Participants had been certified athletic training practitioners for 6 ± 3 years. Most participants had research (N = 9) or teaching (N = 8) assistantships. Others (N = 5) reported a split between teaching and research, while 2 participants were funded based upon clinical responsibilities. Data saturation guided the total number of participants recruited. **Data Collection and Analysis:** We conducted semi-structured telephone interviews with all participants. Interviews lasted 45-60 minutes and were recorded and transcribed verbatim. After reaching saturation, data was analyzed independently by two researchers using a general inductive approach. We utilized multiple analyst triangulation as well as peer review to establish credibility. **Results:** Four primary themes emerged from the data: 1) there is a limited understanding of the guidelines and criteria for tenure and promotion, 2) knowledge of guidelines and criteria is perpetuated by mentoring, 3) research/scholarship is perceived as paramount for success, and 4) the belief that skills gained can facilitate success in other areas, regardless of the domain of tenure. **Conclusions:** Our findings suggest that doctoral students in athletic training are partially aware of the guidelines for tenure and/or promotion, but could benefit from additional mentoring about future role expectations in all areas. We recognize that institutional tenure expectations will likely be reviewed with faculty members once they gain employment, however a more robust understanding of tenure expectations may help facilitate successful transition into the professoriate. Future research should focus on understanding perceptions of and experiences with tenure and promotion as faculty in athletic training navigate the process and employment experiences amass.

Transition From Student to Faculty: Socialization Facilitators and Barriers Among Junior Faculty

Kilbourne BF, Mazerolle SM, Bowman TG: Emory & Henry College, Emory, VA; University of Connecticut, Storrs, CT; Lynchburg College, Lynchburg, VA

Context: New athletic training faculty are expected to teach, serve, and be productive scholars in order to earn tenure, but few experience the full spectrum of faculty responsibility until their first job. At this point, little is known about the facilitators and barriers to the transition of athletic training junior faculty. **Objective:** Examine the facilitators and barriers to junior faculty transition from doctoral student to faculty member. **Design:** Exploratory qualitative study. **Setting:** Higher education institutions. **Patients or Other Participants:** 16 junior faculty (7 male, 9 female, age = 32 ± 3.5 years) representing 7 National Athletic Trainers' Association districts participated. Twelve participants were in tenure track and 4 had a non-tenure track position. Five reported positions with a research focus and 11 reported positions with a teaching focus. At the time of the interview participants were within their first 3 years of a full-time faculty position. Data saturation was reached. **Data Collection and Analysis:** All participants completed a semi-structured interview over the phone. The interview guide was focused on the experiences of junior faculty and was developed based upon the literature and purpose of the study. All transcribed interviews were analyzed using a general inductive approach; a process completed by 2 researchers independently. Multiple analyst triangulation and peer review were used to ensure trustworthiness. **Results:** Facilitators and barriers to junior faculty transition fell within 3 specific categories: 1) doctoral program

characteristics, 2) employer characteristics, and 3) individual characteristics. Doctoral program facilitators included programs that provided comprehensive experience, and course work related to pedagogy and higher education administration. Doctoral program barriers resulted from doctoral preparation that lacked course preparation experience, feedback related to teaching, and information related to institutional bureaucracy. Employer characteristics that facilitated transition included mentoring and orientation. Lack of clearly stated expectations and evaluation, and lack of adequate mentorship and/or orientation were barriers to full socialization. Individual characteristics that facilitated transition were seeking experience that matched career goals (e.g., clinical, teaching, administration, etc. experiences before and during doctoral training) that match future career goals, access to and reliance on a social network (e.g., continued support from personal and professional relationships such as former classmates, spouses, doctoral mentor, family, former employer, etc.), and adaptive perfectionism (i.e. the adaptations of personal expectations). **Conclusions:** Our findings support the need for support of aspiring faculty members within their doctoral preparation (experiential and pedagogically), and support from their employers through professional socialization as the transition can be stressful. Additionally, based on the individual characteristics, advising students within their professional programs about the importance of experience that is congruent with goals, networking, and time management may strengthen professional persistence.

Finding Work-Life Balance Among Junior Athletic Training Faculty

Mazerolle SM, Bowman TG, Kilbourne BF: University of Connecticut, Storrs, CT; Lynchburg College, Lynchburg, VA; Emory & Henry College, Emory, VA

Context: Work-life balance (WLB) has garnered attention among faculty working in higher education institutions. The American Association of University Professors acknowledges the uniqueness of a faculty role, which is seemingly viewed as immeasurable creating challenges with finding an appropriate balance between family, personal, and career expectations and obligations. Although WLB has been stereotyped as gendered, both males and females can struggle finding it and those who have just transitioned to new professional positions are at greater risk for conflict (i.e. junior faculty). **Objective:** Examine role balancing among athletic training faculty who have just entered their role within higher education institutions. **Design:** qualitative study **Setting:** 14 higher education institutions **Patients or Other Participants:** 16 junior faculty (7 male, 9 female) representing 7 National Athletic Trainers' Association districts participated. The average age of the junior faculty member was 32 ± 3.5 years. 12 were in tenure track and 4 had non-tenure track positions. Ten of the participants were married to spouses that were employed or students (7 full-time; 3 part-time). Four participants had children. At the time of the interview each were within their first 3 years of a full-time faculty position. Data saturation was reached. **Data Collection and Analysis:** All participants completed a semi-structured interview over the phone. The interview guide was focused on the experiences of junior faculty and was developed based upon the literature and purpose of the study. All transcribed interviews were analyzed using a general inductive approach; a process completed by 2 researchers independently. Multiple analyst triangulation and peer review were used to ensure trustworthiness. **Results:** Conflict was generated because of 3 factors: 1) learning a new role and expectations accompanying the role, 2) workload related to balancing research and teaching, and 3) upcoming deadlines. Conflict was simply a result of role inductance and role overload due to expectations in various aspects of the faculty role (i.e., teaching and research). Creating balance was done via 4 methods: 1) being effective time managers by planning and making to do lists and 2) surrounding themselves with good mentors and supportive individuals, at home and in the workplace, 3) having a social or non-work outlet, and 4) taking advantage of a flexible work schedule. **Conclusions:** New faculty can experience increased levels of stress, which can contribute to struggles finding WLB. Our results speak to the consistency of connecting work overload and long hours to conflict; something that permeates all working professionals. Higher education institutions, however, offer a more flexible environment that serves as a buffer to finding balance unlike more traditional athletic training practice settings. Much like the research, our findings demonstrate the need for support and outside interests in establishing work-life balance.

Effective Formal Mentoring in Higher Education: Perspectives From Participants of the NATA Foundation Research Mentor Program

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Context: Mentoring is a beneficial mechanism to support junior faculty members as they navigate job expectations, institutional nuances, and the professional landscape during their role transition into higher education. Institutions or professional organizations may implement formal mentoring programs to create connections between professionals. While effective characteristics of informal mentoring relationships are generally understood, less is known about factors that contribute to formal mentoring relationships. **Objective:** Gain perceptions of effective mentoring in a formal setting, specifically attractors to the program and the value of the relationships, from the perspectives of mentors and mentees participating in such programs. **Design:** Qualitative phenomenology. **Setting:** Higher education institutions. **Patients or Other Participants:** Participants of the 2015 National Athletic Trainers' Association (NATA) Foundation research mentor program cohort, which pairs mentees with mentors, were purposefully sampled. 10 of 12 individuals agreed to participate in the study. Mentees included 4 women and 2 men with 3 ± 4 years in their current faculty position. Mentors included 2 women and 2 men with an average of 10 ± 3 years in their current faculty position. **Data Collection and Analysis:** Participants completed one telephone interview prior to starting the mentor program and one interview upon completing the program 11 months later. Participants also completed 3 structured online journals at 3-month increments throughout their participation in the program. We analyzed data using a general inductive approach. We used peer review and pilot testing of the interview guides, member checking, and multiple analyst triangulation for credibility. All 3 investigators agreed data saturation was obtained. **Results:** Mentors completed the program as a way to stimulate collaboration and give back to the athletic training profession. Mentees sought out the program as a means to gain support in their research endeavors and to stimulate networking opportunities. Participants described that regular communication, clear expectations, and investment in the relationship were characteristics of effective mentors and mentees. Participants who collaborated on scholarly activities during their mentoring experience perceived this to be a highly valuable aspect of their experience that facilitated regular communication and the potential for a long-lasting relationship. While mentoring was focused on professional development, personal connections enriched participants' mentoring experiences. **Conclusions:** The NATA Foundation research mentor program offers a mutually beneficial experience for mentors and mentees. Overall, participants were satisfied with their experiences as they felt they were able to meet the initial objectives established at the outset of the program. Mentee participants recognized the program gave them a chance to gain an external perspective and advance their research agendas while mentors learned from their mentees and were able to use the program as a means to gain professional service. Participants of formal mentoring programs should be encouraged to exhibit effective mentoring characteristics.

Peak Resultant Linear Acceleration Agreement Between Common Head Impact Sensor Devices

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Context: A number of different head impact sensor devices measuring head impacts related to concussion risk are commercially available. It remains unclear how well the measurement agreement between these devices are, and if valid head impact magnitude comparisons can be made between studies utilizing different devices. **Objective:** To correlate measures of peak resultant linear acceleration (PRLA) between three head impact sensor devices. **Design:** Repeated measures. **Setting:** Laboratory. **Patients or Other Participants:** Three cadaveric head specimens. **Interventions:** Impacts were delivered through controlled laboratory drops to the cadaver head specimens wearing a Riddell Speed football helmet. Three impact devices concurrently measured each drop: the Head Impact Telemetry System (HITS), the X2 Biosystems xPatch (xPatch), and the Triax Technologies Sim-G (Triax). Each helmeted specimen was dropped onto six locations (facemask, front oblique right, front, occipital, right parietal, and vertex) from 3 drop heights (10, 60, and 100 cm). The HITS was coupled directly to the inside of the helmet. The xPatch was adhered over the mastoid process behind the right ear. The Triax was coupled to the specimen with a skullcap and positioned over the external occipital protuberance. Our independent variable was sensor type (HITS, xPatch, Triax). **Main Outcome Measures:** Linear regression analyses compared the PRLA measured by each device for all drops (overall) and stratified by drop location for each device comparison. The slope (m) of the regression estimated the accuracy and the coefficient of determination (R^2) estimated the strength of the association between devices. Perfect device comparisons would yield little overestimations/underestimations of PRLA (m = 1.00; R2 = 1.00; Intercept = 0). Only drops where all 3 devices recorded data were used in the regression analyses. **Results:** All three devices recorded data in 48% of the drops (104/216). Triax and xPatch had the strongest overall association (R^2 = 0.82), but Triax underestimated PRLA by 30% in comparison to xPatch. The HITS and xPatch were moderately associated (R^2 = 0.64), with xPatch overestimating PRLA by 17% compared to HITS. Triax and HITS had the weakest association (R^2 = 0.58), with Triax underestimating PRLA by 19% compared to HITS. Associations between devices depended on drop location. On average, device associations were stronger at the front oblique right location ($R^2 \geq 0.77$, n = 21). Comparisons made at the occipital drop location had little association ($R^2 \leq 0.09$, n = 22). **Conclusions:** Overall associations between devices were moderate, but we observed wide variation stratified by drop location. Low associations could be due to each device using their own algorithms to estimate PRLA experienced at the head center of gravity, in addition to their own head-coupling mechanisms. Caution should be used interpreting head impact biomechanics between studies using different devices. Additional algorithms could be developed to relate head impact kinematics from different devices and provide more comprehensive head impact exposures within a sport.

A Helmetless Tackling Training Intervention to Decrease Head Impacts in American Football: Year 2

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Context: While a helmet is necessary in football, a novel training intervention performed without helmets is hypothesized to positively modify behavior for avoiding head impact. **Objective:** To study the effectiveness of an ongoing helmetless tackling training (HuTT®) intervention to reduce head impact exposure in collegiate football. **Design:** A 2-year, prospective, randomized investigation. **Setting:** NCAA Football Championship Series Division I collegiate football. **Patients or Other Participants:** Thirty-nine participants that completed 2 years of the study maintained their randomized group assignments stratified by position [HuTT-immediate = 20 (9 Offense, 11 defense), HuTT-delayed = 19 (3 Offense, 16 defense]. **Interventions:** HuTT-immediate participants received the intervention in Years 1 and 2, while HuTT-delayed participants served as controls in Year 1 and crossed over to the intervention for Year 2. The HuTT® intervention consisted of performing a 6-8 minute tackling and blocking session without a helmet twice/week during pre-season and once/week throughout the competitive season. Drills involved executing tackling and blocking techniques at varying intensity against an upright pad, padded shield held by teammate, or field apparatus. Drills were supervised by trained football coaching staff. Participants wore an xPatch™ impact sensor to record head impacts sustained during each practice and game. Attendance for interventions and practices/games were recorded. **Main Outcome Measures:** Frequency of all impacts ≥10g of linear

acceleration were filtered and exported. Remaining spurious impacts were identified and removed. Athlete exposure, head impact frequency (ImpFreq) and frequency of head impacts per athlete exposure (ImpFreqAE) were compared between groups at three time-points (pre, mid, and end of season) using repeated measures analysis of variance (ANOVA). Interactions ($P < 0.05$) and main effects were followed with appropriate t-tests. **Results:** There were no time x group interactions for AE, ImpFreq and ImpFreq AE. AE was at highest mid-season ($26.4 + 5.3$; $P < .01$) and similar at pre ($18.0 + 4.7$) and post ($18.2 + 5.7$) season ($P = .92$). ImpFreq ($P < .001$) changed from 259.8 ± 139.7 at pre, to 431.0 ± 213.9 ($P < .01$) at mid-season, then decreased at the end of the season (292.85 ± 194.5; $P < .01$). When impacts were controlled by exposures (ImpFreqAE), there were no changes over the course of the season ($P = .06$) and there were no differences ($P > .05$) between the groups at each time-point (HuTT-immediate ImpFreq AE: pre = 13.2 ± 6.6, mid = 14.9 ± 6.3, end = 13.1 ± 7.2, HuTT-delayed ImpFreq AE pre = 15.2 ± 6.5, mid = 17.2 ± 8.3, end = 17.5 ± 9.7). **Conclusions:** While ImpFreq decreased at the end of the season compared to mid-season, these changes are likely attributed to a variation in AE. Additionally, an imbalance in player position (offense vs defense) may have tempered differences between the groups. Longer duration studies across multiple teams, player position, and levels of play (youth, high school) are necessary to determine the effectiveness of helmetless tackling training.

Subconcussive Impact Dependent Increase in Plasma S100B Expression in Collegiate Football Players

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Context: Trauma-induced astrocyte activation upregulates the astrocyte-enriched protein, S100β, in the brain. Brain-derived S100β in the blood stream may reflect brain injury but the relationship between subconcussive impact kinematics and plasma S100β levels is unknown. **Objective:** To examine our hypothesis that the increase in plasma S100β levels would be significantly correlated with frequency and magnitude of subconcussive head impacts sustained. **Design:** Prospective cohort study **Setting:** Clinical/Field **Patients or Other Participants:** Twenty-two Division-I collegiate football players (mean age, 20.6+/-1.5 years old) volunteered to participate and signed an IRB approved consent form. **Interventions:** The independent variables were time (11 time points) and group (lower versus higher impact). During pre-season physical screening, participants were fit with the Vector mouth guard (10 g threshold) that recorded head impact kinematics during five practices, with 3-4 day interval between each data collection practice. Based on the kinematic data, players were categorized into lower ($n = 7$) and higher ($n = 23$) impact groups (number of impacts, 6.0 +/- 5.6 vs. 43.1 +/- 18.3, $p < .001$; average peak linear acceleration for 5 practices, 99.4 +/- 181.6 g vs. 1148.5 +/- 558.1 g, $p < .001$; average peak rotational acceleration for 5 practices, 7,589 +/- 6112 rad/s 2 vs. 68,259 +/- 29,696 rad/s2, $p < .001$, respectively). **Main Outcome Measures:** The blood samples were collected and assessed for S100β levels at baseline and pre-post practices for 5 practices; symptom scores were assessed at each time point. **Results:** There was significantly higher level of plasma S100β in the post-practices (Avg. 0.111 + 0.01 ng/mL) compared to pre-practice S100β level, (Avg. 0.048 + 0.01 ng/mL; $t21 = 6.021$, $p < 0.001$). The acute changes in plasma plasma S100β were significantly and positively correlated with the number of hits ($r = 0.636$, $p = .001$), sum of peak linear acceleration ($r = 0.570$, $p = .006$), and sum of peak rotational acceleration ($r = 0.655$, $p = .001$). When plasma S100β levels at each time point were compared to the pre-season baseline using post-hoc Dunnett's tests, S100β levels remained stable from baseline to all pre-practice time points ($p > .14$), but significant increases in S100β were observed in all post-practice time points ($p = .01$) compared to the baseline. To examine whether changes in S100β at post-practices were driven by head impact exposure, head impact groups (higher vs. lower) on time points were tested using 2 x 11 repeated measures ANOVA. There was a statistically significant group by time interaction, $F(10, 200) = 3.19$, $p = .001$. Follow-up one-way ANOVAs within group indicated a significant time effect for the higher impact group, $F(10,164) = 24.21$, $p < 0.001$, but not for the lower impact group, $F(10,76) = 2.503$, $p = 0.165$. In the higher impact group, S100β level remained stable from baseline to all pre-practice time points ($p > 0.51$), suggesting there were no cumulative effect of subconcussive head impact. However, significantly higher S100β levels were observed in all post-practice compared with the baseline ($p = 0.01$). **Conclusions:** Assessing the effects of repetitive subconcussive head impacts on acute changes in S100β levels may be a clinically useful blood biomarker in tracking real-time acute brain damage in collegiate football players.

Concussive Head Impact Biomechanics in Women's Lacrosse and Soccer Athletes

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Context: Head impacts and concussions have become an increasing topic of interest recently. Despite the literature on head impacts in sports, there is limited research on the biomechanics of concussive impacts in women. To date, most studies regarding concussion biomechanics have been conducted on male participants. **Objective:** To investigate the biomechanics of concussive head impacts in women's lacrosse and soccer athletes. **Design:** Descriptive epidemiology study. **Setting:** Collegiate athletic fields. **Patients or Other Participants:** 4 National Collegiate Athletic Association Division III women's soccer and lacrosse athletes (age = 19.20 ± 1.10 years, height = 64.00 ± 1.58 cm, weight = 59.09 ± 2.55 kg) **Interventions:** Participants of a larger study wore xPatch sensors (X2 Biosystems Inc., Seattle, WA) during all games and practices. There were four total concussions during the two seasons of play, two concussions in soccer (fall 2014 and fall 2015) and two in lacrosse during the spring 2016 season. All games and practices were video recorded for verification of concussive events. Two of the concussive impacts occurred during games and two of the concussive impacts occurred during practices. All participants sustained a concussion as diagnosed by an athletic trainer and confirmed by a physician. **Main Outcome Measures:** Magnitude (linear acceleration (LA) in g and rotational acceleration (RA) in deg/s^2) and location of head impact. We used the LA and RA to calculate the impact ranges, means, and standard deviations. **Results:** The average LA for all concussive head impacts was 30.46 ± 30.92 g and the average RA was 189003.50 ± 268097.48 deg/s^2. The average LA for the women's lacrosse athletes was 46.16 ± 42.95 g and the average RA was 420243.00 ± 376088.88 deg/s^2. The average LA for the women's soccer athletes was 30.46 ± 30.92 g and the average RA was 198796.05 ± 158578.52 deg/s^2. The range for LA was 10.46 g - 76.53 g and the range for RA was 86664.10 deg/s^2 - 686178.00 deg/s^2. Three of the concussions occurred from impacts to the side of the head and one resulted from a frontal impact. **Conclusions:** We speculate that the differences in the rotational and linear acceleration between the women's soccer and lacrosse athletes can be attributed to the differences in style of play. Our results also indicate the average LA and RA that caused the athletes to suffer concussions is much lower than those reported in the literature for professional football (LA of 61-144 g), collegiate football (LA of 61-169 g), and high school football (LA of 61-169 g). These results suggest concussions are heterogeneous from a mechanism standpoint, especially across sex.

Assessment of Youth Football Helmet Fitting Quality

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Context: Properly fit football helmets are critical for injury prevention. Individuals responsible for properly fitting protective equipment have a broad range of training and expertise, particularly in youth sports, where a majority of coaches are volunteers with little to no formal education regarding equipment fitting. **Objective:** The objective of this study was to examine the appropriateness of football helmets fit by two experienced youth football coaches as determined by athletic trainers' (AT) examination. **Design:** This study was a cross-sectional analysis. **Setting:** Data was collected during a pre-season session in which youth football players were fit with football equipment. **Patients or Other Participants:** Subjects in this study included 55 youth football players aged 6-13 years (53 males, average age 9.65 ± 1.64 years). Subjects participated at one of four levels based on age and experience: Junior Peewee (JPW) ages 6-8, Peewee (PW) age 9, Junior Varsity (JV) ages 10-11 and Varsity (V) ages 11-13. **Interventions:** Subject's helmets were examined by three AT who assessed ten areas for proper fit with each AT examining the same criteria on each helmet to assure intra-tester reliability. These areas included: visual inspection of shell, fit of frontal pad, fit of cheek pads, alignment of ear holes, position of occipital pad, obstruction of vision, alignment of chinstrap, spacing of facemask, lateral movement of helmet and recoil of helmet. Each area was scored as either pass (1 point awarded) or fail (0 points awarded). Each helmet was given an overall score based on the number of areas passed, with a perfect score of 10 indicating a helmet that was successfully fit for athlete safety. **Main Outcome Measures:** The main outcome measures were the score for

each of the ten individual assessments and the total score for the overall fit of the helmet. **Results:** Only 9/55 (16%) of all helmets met the criteria for being appropriately fit. Average score for all helmets was 7.67 ± 1.74. Most common areas for helmet failure included: obstructed vision (47% pass rate), chinstrap alignment (69%), lateral movement (53%) and recoil (64%). Statistical analysis using t-tests comparing JPW/PW (under age 10) to JV/V (over age 10) subjects demonstrated younger athletes' helmets were more likely to fail in areas of lateral movement and recoil ($p<0.05$) and have a lower overall score ($p=0.03$). **Conclusions:** Results of this study suggest that youth football helmets fit by experienced volunteer coaches do not meet commonly accepted standards for injury prevention. The findings also suggest that properly fitting football equipment on younger athletes is more challenging than fitting equipment on older athletes. The results strongly suggest the need for additional training of youth coaches and /or the need for more athletic trainers involved in injury prevention in youth football.

Training Alone May Not Lead to Meaningful Change: Coaches' Implementation of the USA Football "Heads Up Football" Educational Program

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Context: An integral part of USA Football's Heads Up Football (HUF) intervention is the Player Safety Coach (PSC), who is responsible for teaching other coaches within a youth football league about injury prevention, including safer blocking/tackling. **Objective:** This study examined the association between youth football coaches' interactions with the PSC and their subsequent implementation of the HUF intervention. **Design:** Cross-sectional study. **Setting:** Youth football leagues during the 2015 season. **Patients or Other Participants:** All 100,288 coaches in HUF leagues during the 2015 season were invited to complete an online questionnaire. Of the 1,316 (1.3%) completing the questionnaire, most were male (97.9%), White Non-Hispanic (73.9%), 40-49 years old (54.3%), first aid-/CPR certified (56.0%), and coached for at least two years in a HUF league (53.1%). **Interventions:** An online questionnaire was developed with feedback from USA Football and pretested with ten coaches. Respondents answered questions pertaining to: attendance at the PSC-sponsored education clinic at the beginning of the season and regularly seeing the PSC on-field during practices (both being core elements of disseminating the HUF intervention); and implementation of each facet of the five main components of the HUF intervention (Concussion recognition/response, Equipment fitting, Heads Up tackling/blocking, Heat preparedness and hydration, Sudden cardiac event preparedness). **Main Outcome Measures:** Logistic regression models estimated odds ratios (OR) and 95% confidence intervals (CI), with education clinic attendance and PSC on-site presence serving as the independent variables, full implementation of each of the five HUF intervention components serving as the dependent variables, and CPR/first-aid certification and years coaching in HUF leagues as covariates. **Results:** In the 2015 season, 44.8% did not attend the education clinic, with common reasons including: not being aware clinic was offered (58.9%) and too busy with other personal activities (17.4%). Also, 25.9% reported not regularly seeing their league's PSC on-field during practices. Full implementation ranged from 78.1% for "Sudden cardiac event preparedness" to 97.4% for "Heads Up tackling/blocking". PSC on-site presence was associated with higher odds of full implementation of "Concussion recognition/response" (OR = 2.85; 95% CI: 1.79-4.53), "Heat preparedness and hydration" (OR = 3.31; 95% CI: 1.90-5.78), and "Sudden cardiac event preparedness" (OR = 2.14; 95% CI: 1.57-2.91). CPR/first-aid certification was associated with higher odds of full implementation of "Equipment fitting" (OR = 2.13; 95% CI: 1.18-3.83) and "Sudden cardiac event preparedness" (OR = 1.33; 95% CI: 1.01-1.76). Education clinic attendance and years coaching in a HUF league were not associated with implementation. **Conclusions:** Presence of the PSC may be an integral part of the HUF intervention. Yet, opportunities exist for improvement in the HUF intervention, as there was inconsistent implementation and no effect found from education clinic attendance. Further research is warranted to understand how to optimize the role of the PSC and the education clinic in the youth sports context.

Ankle Kinematics and Kinetics During Walking Before and After Exercise

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Context: The ankle plays an important role in providing stability and mobility during the gait cycle. Fatigue may affect ankle biomechanics during the gait cycle. **Objective:** To compare kinematic and kinetic patterns of the ankle during walking before and after a fatiguing exercise protocol in healthy individuals. **Design:** Descriptive laboratory study. **Setting:** Laboratory. **Patients or Other Participants:** Fifteen healthy individuals (12 females, 3 males, age = 19.4 ± 1.2 years, height = 168.6 ± 9.5 cm, mass = 67 ± 12 kg) participated. **Interventions:** Participants completed a 30-minute exercise protocol that included five bouts of five minutes of treadmill walking at a constant speed of 1.3 m/s with one minute of jump squats and lateral hops performed in between each walking bout. The treadmill incline was increased by 0.5° each minute of walking until the maximum of 8.5° incline was achieved. **Main Outcome Measures:** Frontal and sagittal ankle kinematic and kinetic data were measured throughout the gait cycle utilizing a twelve camera motion capture system and an instrumented treadmill as subjects walked at 1.3 m/s with no incline. Data from each stride were reduced to 101 points to reflect 0-100% of the gait cycle. Means and standard deviations were calculated to show the changes in motion and moments over the span of the gait cycle, both pre and post-exercise. Periods where confidence intervals did not overlap for three or more consecutive points were considered significantly different and mean differences were then calculated. **Results:** Neither frontal not sagittal kinematics and kinetics showed significant changes after exercise. Frontal plane ankle kinematics during the stance phase showed a mean difference of .90° ± .41° in the left foot and.50° ± .50° in the right foot after the exercise protocol, showing both feet to be slightly more inverted post-exercise. Sagittal plane ankle kinematics during the stance phase showed a mean difference of 1.95° ± 1.51° in the left foot and 1.95° ± 1.72° in the right foot, showing both feet to be slightly more dorsiflexed post-exercise. Frontal plane ankle kinetics during the stance phase showed on average a .013 ± .016 Nm/kg change in moment in the left foot, and a .01 ± .02 Nm/kg in the right foot after the exercise protocol, with slightly greater eversion moments in both feet post-exercise. Sagittal plane ankle kinetics during the stance phase showed on average a -.039 ± .074 Nm/kg change in moment in the left foot, and a -.068 ± .10 Nm/kg change in moment in the right foot, showing slightly greater dorsiflexion moments in both feet post-exercise. **Conclusions:** Ankle kinematics and kinetics were not substantially affected following exercise in this healthy group. These findings warrant further research with pathological comparison groups.

Step-Down Task Identifies Differences in Ankle Frontal Plane Kinematics During Walking in Recreationally Active Adults

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Context: Increased inversion during walking may contribute to the high ankle sprain rates and the development of chronic ankle instability. Due to the multi-planar nature of ankle kinematics and the complexity of gait evaluation, there is currently no clinical assessment tool to identify excessive inversion during gait. We previously demonstrated that inversion during a step-down task is strongly correlated to inversion during walking and we hypothesized that the step-down task may be simpler than gait evaluation for identifying excessive inversion kinematics. **Objective:** Determine whether a step-down task using simple yes/no scoring criteria can identify differences in ankle frontal plane motion during walking. **Design:** Descriptive-laboratory. **Setting:** Laboratory. **Patients or Other Participants:** Fifty-seven recreationally active adults (gender = Male: 27; Female: 30, age = 21.2 ± 3.2 years, height = 171.3 ± 8.0 cm, mass = 75.6 ± 15.4 kg). We included individuals with and without a history of LAS to ensure a wide range of frontal plane motion was represented in our analysis. **Interventions:** Three-dimensional ankle frontal plane kinematics were assessed during 15 walking and step-down trials. Walking trials were completed at a self-selected pace over a 6M walk-way with an embedded forceplate used to determine initial-contact. For the step-down trials, individuals were instructed to look at an eye-level target, step-off a 30cm step and continue walking forward. During the step-down task, a 2D video camera placed beneath

the step recorded a posterior view of ground contact. Following data collection, a random 2D-video of each participant was analyzed by a blinded-reviewer. The reviewer was instructed to watch each video frame-by-frame, and to score the video as "Lateral" if the participant's first point of contact with the ground was made by the outer 1/3rd of their shoe or "Non-Lateral" if any other part of the shoe first came into contact. Based on the reviewer's score, two groups were formed (Lateral or Non-Lateral). **Main Outcome Measures:** Ankle frontal plane kinematics during walking was compared between the two groups. Kinematic data was re-sampled to 100 frames where each frame represented 1% of the gait cycle. Differences between groups were assessed by using a time-series analysis that compared group means and associated 90% confidence intervals (CIs) across all 100 frames. Areas where CIs between groups did not overlap for 3 consecutive time points were considered significant. **Results:** The lateral group had significantly more inversion during initial-contact ((Peak mean difference±CI; % of cycle): 5.0 ± 0.9º; 1-6%) and mid-stance through terminal swing ((Peak mean difference ± CI; % of cycle): 6.1 ± 1.3º; 22-100%) than the non-lateral group. **Conclusions:** This study found that individuals who make 1st contact with the outer 1/3 of their shoe during a step-down task have significantly more inversion during gait than individuals who do not. This is the first study to show that a clinical screening tool can identify differences in frontal plane kinematics during walking.

Combined High-Intensity Strength Training and Gait Retraining Improves Strength, But Not Walking Biomechanics, in Individuals With Anterior Cruciate Ligament Reconstruction: A Case Series

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Context: Individuals with anterior cruciate ligament reconstruction (ACLR) demonstrate greater self-reported disability and are 5x more likely to develop posttraumatic osteoarthritis. Despite completing traditional rehabilitation and returning to physical activity (PA), quadriceps weakness and aberrant gait biomechanics persist for years following ACLR and likely contribute to poor long-term outcomes. Verbal feedback improves jump-landing biomechanics, and high-intensity strength training is advantageous for improving strength. It remains unknown if verbal feedback can modify gait biomechanics, and if simultaneous improvements in quadriceps strength and gait biomechanics can be achieved in ACLR individuals who have returned to PA. **Objective:** To assess changes in quadriceps strength and gait biomechanics following a 6-week high-intensity lower extremity strength training and gait retraining intervention in individuals with ACLR who have returned to unrestricted PA. Secondarily, we assessed if changes in quadriceps strength associated with changes in gait biomechanics. **Design:** Case Series. **Setting:** Research Laboratory. **Patients or Other Participants:** Seven females with ACLR (age = 21.28 ± 3.68 years, height = 1.61 ± 0.05 m, mass = 63.58 ± 5.14 kg, 48.83 ± 29.93 months post ACLR). **Interventions:** Participants attended two sessions per week for 6 weeks (12 total sessions). High-intensity strength training (80% of one-repetition maximum) consisted of three sets of 8-10 repetitions for squats, knee extension and hamstring curl. For gait retaining participants walked at self-selected speed on a treadmill, and were provided verbal feedback to promote symmetry in sagittal plane kinematics (knee flexion angle at initial contact [flex_IC]; knee flexion excursion [flex_EXCURSION]) and vertical ground reaction force (vGRF). **Main Outcome Measures:** All outcomes were assessed before and following the twelfth intervention session (mean = 4.14 ± 1.07 days). Quadriceps strength was assessed isometrically at 90° of knee flexion. Lower extremity biomechanics, including peak vGRF, flex_IC and flex_EXCURSION were calculated during the first 50% of the stance phase of walking gait. We calculated limb symmetry index (LSI [reconstructed limb/contralateral limb]) at baseline and 6-weeks, as well as percent change from baseline to 6-weeks ([6-Weeks – Baseline]/Baseline*100) for each outcome. Dependent samples t-tests were used to assess changes in strength from baseline to 6-weeks. One-way repeated measures ANCOVAs were used to assess changes in biomechanical outcomes while controlling for changes in gait speed. Pearson product moment correlations were used to determine associations between percent change in strength and biomechanical outcomes. Alpha level was set a priori ($P \leq 0.05$). **Results:** Quadriceps strength significantly improved from baseline (mean = 1.82 ± 0.56 Nm/kg) to 6-weeks (mean = 2.36 ± 0.57 Nm/kg; $P = 0.019$). No gait biomechanics were significantly different from baseline to 6-weeks ($P > 0.05$). Changes in quadriceps strength did not significantly associate with changes in biomechanical outcomes (r range = -0.075 to 0.174). **Conclusions:** Quadriceps strength can be improved in ACLR individuals who have returned to PA, however verbal feedback did not change gait biomechanics. More sophisticated methods of gait retraining or additional sessions may be necessary to alter gait biomechanics.

The Effects of 9-Week Cadence Training on Biomechanics in Novice Runners

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Context: For runners, finding the ways to reduce stress and preventing injuries is imperative. While increasing running cadence (steps/min) is suggested to improve running kinematics and reduce overall forces acting on the body, few studies have actually investigated the effects of a longer-term cadence training on running mechanics, especially among novice runners. It is necessary to establish how manipulation of cadence would have an effect on novice runners' mechanics over an extended period of time. **Objective:** To investigate the effects of a 9-week progressive running training program focused on increased cadence, on kinematics and ground reaction forces in novice runners. **Design:** Non-controlled clinical trial. **Setting:** University research laboratory. **Patients or Other Participants:** Eighteen female novice runners (Age = 19.94 ± 0.80 years; Mass = 64.91 ± 7.33 kg; Height = 1.66 ± 0.64 m; BMI = 23.51 ± 2.75) participated in the study. **Interventions:** Participants reported for data collection twice, prior to and immediately after the 9-week progressive running training focused on increased cadence (cadence training). Force platforms and 3-D motion capture system were used to record the kinematic and force data, while the participants ran across the laboratory space at a self-selected pace. During the baseline (Pre) testing, each participant's initial cadence at the self-selected pace was determined. The participant was instructed to run 3 times a week at 110% of the initial cadence throughout the 9-week cadence training period. At the end of the 9-week cadence training (Post), the participant's running biomechanics and cadence were recorded at the same running speed as the baseline. **Main Outcome Measures:** Dependent variables included running cadence (steps/min), peak vertical ground reaction force (vGRF) normalized to body weight (BW), and sagittal and frontal plane kinematics (degrees) of ankle (dorsiflexion/plantarflexion, inversion/eversion), knee (flexion/extension, valgus/varus) and hip (flexion/extension, abduction/adduction) at the peak vGRF. The independent variable was time (Pre- and Post-cadence training). For each dependent variable, a separate paired-samples t-test was used to detect differences. The level of significance was set apriori at $P < 0.05$. **Results:** The 9-week cadence training resulted in a significant increase in cadence at the same running speed (Pre = 159.67 ± 9.78 steps/min, Post = 164.61 ± 9.20 steps/min; $t = -3.037$, $P = 0.007$). The 9-week cadence training also resulted in a significantly lower peak vGRF (Pre = 2.22 ± 0.21 BW, Post = 2.12 ± 0.18 BW; $t = 2.77$, $P = 0.013$). There was no effect of cadence training on any of the lower extremity kinematics in the sagittal and frontal planes ($P > 0.05$). **Conclusions:** Although no kinematic differences were observed, the 9-week cadence training resulted in slightly lower peak force exerted during running. Given that no participant sustained injury during training, the reduction in force may be helpful in allowing the novice runners to run more efficiently. The preventative effects of force reduction via increased cadence may be suggested; however, further prospective studies are warranted.

Stride Frequency and Lower Extremity Injury in Collegiate Distance Runners

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Context: Distance runners are at a high risk for overuse injuries, especially in collegiate cross-country and track and field. While some research supports that fewer strides leads to greater stress at the knee, there are no longitudinal studies to suggest a higher incidence of injury. One modifiable biomechanical factor is stride frequency (SF), but it is unclear whether SF is predictive of running related injury. **Objective:** The purpose of this practice-based investigation was to examine the relationship between SF and lower extremity injury during a competitive track and field season. **Design:** Practice-based research with retrospective data analysis. **Setting:** Division I Athletic Training Facility. **Patients or Other Participants:** Division I collegiate cross country runners (n = 26, 11 female; age = 19.5 ± 0.8 years; height = 169.09 ± 7.8 cm; weight = 56.8 ± 4.9 kg; SF = 173.6 ± 9.8; 15 male; age = 19.6 ± 1.3 years; height = 179.60 ± 5.80 cm; weight = 71.20 ± 5.38 kg; SF = 168.3 ± 8.6) in good academic standing and eligible for the 2016 outdoor track and field season. Any patient with activity restrictions at the time of pre-participation screenings were not included. **Interventions:** Prior to the initiation of the 2016 competitive outdoor track and field season stride frequency was measured using a treadmill and 2-D video analysis. To capture SF all participants ran on a treadmill for 3 minutes. Participants were asked to use a pace closest to their long run pace (>4 miles). Injuries were classified using the Orchard Sports Injury Classification System (OSICS-10) and recorded from March to June 2016. **Main Outcome Measures:** With video editing software, a chronograph was overlaid onto the recording and used to count footstrikes for two 30-sec sections of running. The mean of the two sections was

used to calculate the SF. Lower extremity injuries were classified as any lower extremity injury diagnosed by either the athletic training staff or team physicians that warranted at least 1 day of modified practice or competition. Injuries were recorded using the OSICS-10 transcribed into a Qualtrics survey and extracted at the conclusion of the competitive season. Injury data was used to separate those that sustained a lower extremity injury and those that did not during the competitive season into two groups (injured, uninjured). We used an independent-samples t-test to compare SF between the injured and uninjured groups (injured = 14; uninjured = 12). Significance was set a priori at $p = 0.05$. **Results:** There was no significant difference in SF ($t24 = 0.102$, $p = 0.920$, $1\text{-}\beta = 0.920$) between the injured group (mean = 170.7 ± 8.7 steps/min) and the uninjured group (mean = 170.3 ± 10.5 steps/min). **Conclusions:** While SF may play a role in physical performance, it appears based on our findings that SF does not directly influence the development of lower extremity injury. Other factors such as BMI >30kg/m2, navicular drop, or previous injury should be considered as possible risk factors for lower extremity injury in collegiate cross country runners.

Validation of a Wearable Sensor for Measuring Running Biomechanics

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Context: Many clinicians aim to analyze running biomechanics, but this has traditionally been done in laboratory settings which are dependent on expensive equipment and may not reflect running in natural environments. Wearable sensors may offer a solution to these concerns. **Objective:** To validate the RunScribeTM (RS) wearable sensor for analysis of gait mechanics as compared to a marker-based 3D motion capture (MC) system. **Design:** Concurrent validation study. **Setting:** Laboratory. **Patients or Other Participants:** Twelve recreational runners (6 male, 6 female; age = 23.1 ± 5.5 years, weekly mileage = 16.1 ± 9.3) who were free of lower extremity musculoskeletal injury within the past 12 months participated. **Interventions:** The RS contains a triaxial accelerometer and gyroscope with onboard processing and memory capabilities. The devices were heel-mounted on running shoes and collected data from each step as subjects ran on an instrumented treadmill. Gait kinematics were simultaneously measured from captured reflective marker locations sampled at 250 Hz using a 12 camera MC system. Ground reaction forces were collected by a force plate embedded under the treadmill belt and sampled at 1000 Hz. Participants completed a 1.5-mile run at a self-selected pace. Ten consecutive strides from each limb were collected for analysis at the 1-mile mark. **Main Outcome Measures:** Kinematic variables assessed were pronation excursion (initial contact to maximum pronation) and maximum pronation velocity, while spatiotemporal variables assessed were contact time and cycle time. Measures from the RS and MC system were compared using intraclass correlation coefficients (ICC3,1) for the mean values from each limb across the 10 steps. Bland-Altman analyses were performed to estimate mean differences and associated limits of agreement between the two measurement devices. **Results:** Means and standard deviations across the 10 steps for each variable were: pronation excursion (Right: RS = 13.1 ± 5.8°, MC = 13.7 ± 8.9°; Left: RS = 10.6 ± 5.3°, MC = 14.6 ± 7.6°), maximum pronation velocity (Right: RS = 510 ± 217°/s, MC = 361 ± 188°/s; Left: RS = 444 ± 177°/s, MC = 436 ± 169°/s), contact time (Right: RS = 298 ± 23 ms, MC = 269 ± 22 ms; Left: RS = 292 ± 25 ms, MC = 264 ± 22 ms), and cycle time (Right: RS = 726 ± 26 ms, MC = 723 ± 28 ms; Left: RS = 727 ± 27 ms, MC = 719 ± 28 ms). Strong ICC estimates (left, right) were found for the mean of the 10 steps from each measurement system for maximum pronation velocity (.74, .87), contact time (.93, .92), and cycle time (.94, .91). Pronation excursion demonstrated moderate ICC estimates (.57, .40). Bland-Altman analyses revealed mean differences and 95% limits of agreement estimates for pronation excursion (Right = -1.1° [-18.3°, 16.0°], Left = -4.5°[-18.5°, 9.5°]), maximum pronation velocity (Right = 146°/s [-246°/s, 539°/s], Left = 11°/s [-312°/s, 335°/s]), contact time (Right = 29 ms [-1 ms, 59 ms], Left = 28 ms [-1 ms, 58 ms]), and cycle time (Right = 2 ms [-51 ms,55 ms], Left = 7 ms [-56 ms, 71 ms]). **Conclusions:** The strong ICC estimates and relatively small mean differences found for maximum pronation velocity, cycle time, and contact time, suggest that the RS can be recommended as a useful tool for measuring these variables. Pronation excursion measures were not as consistent across the two measurement platforms.

Gait Mechanics as Measured by a Wearable Sensor While Running at Two Speeds on Different Surfaces

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Context: Running biomechanics research has traditionally taken place in the laboratory, but with the advent of wearable sensors, biomechanics research may be able to move to the field. **Objective:** To determine if RunScribe™, a commercially available wearable sensor, could detect differences in running kinetics and kinematics at different running speeds and on different surfaces. **Design:** Crossover. **Setting:** Field. **Patients or Other Participants:** Fifteen young adults who were recreational runners (7 males, 8 females; age = 20.6 ± 3.0 years, 19.0 ± 12.1 miles run per week) participated. **Interventions:** Each sensor consisted of a triaxial accelerometer and a gyroscope and on-board processing and memory capabilities. Participants wore the sensors on the heels of their personal running shoes while completing two 1600m runs (slow, fast) on two surfaces (track, grass). The order of surface type was randomized. On each surface, the first 1600m was completed at a self-selected slow pace, defined as running at a rating of perceived exertion (RPE) between 3-4 on a 10-point scale, and the second 1600m at a self-selected fast pace, defined as an RPE between 5-6. The four runs were defined as: slow grass (SG), fast grass (FG), slow track (ST), and fast track (FT). **Main Outcome Measures:** Spatiotemporal (contact time, cycle time, stride length), kinematic (pronation excursion [initial contact to maximum pronation], maximum pronation velocity), and kinetic (impact g, braking g) measures were recorded for each step of all runs. Means were calculated across all steps for each 1600m condition. For each measure, a 2 x 2 repeated-measures ANOVA was performed to compare the main effects of speed (slow, fast) and surface (track, grass). **Results:** For the spatiotemporal measures, the sensors were able to detect increased stride length (SG = 2.5 ± 0.4 m, FG = 2.6 ± 0.5 m, ST = 2.4 ± 0.4 m, FT = 2.7 ± 0.5 m; $p < 0.001$) and decreased cycle time (SG = 719 ± 20 ms, FG = 702 ± 26 ms, ST = 707 ± 32 ms, FT = 686 ± 28 ms; $p = 0.01$) and contact time (SG = 293 ± 31 ms, FG = 286 ± 42 ms, ST = 290 ± 32 ms, FT = 273 ± 35 ms; $p = 0.04$) during the fast runs compared to the slow runs. Cycle time ($p = 0.001$) and contact time ($p = 0.04$), but not stride length ($p = 0.93$), decreased on the track compared to the grass. For the kinematic measures, as speed increased, pronation excursion (SG = 11.2 ± 4.9°, FG = 12.8 ± 5.3°, ST = 14.4 ± 5.2°, FT = 16.2 ± 6.2°; $p = 0.002$) and maximum pronation velocity (SG = 378 ± 102°/s, FG = 439 ± 136°/s, ST = 497 ± 215°/s, FT = 607 ± 230°/s; $p < 0.001$) increased. Pronation excursion ($p < 0.001$) and maximum pronation velocity ($p = 0.005$) were higher on the track compared to the grass. Braking g's (SG = 8.5 ± 1.4 g, FG = 9.6 ± 1.7 g, ST = 9.9 ± 1.9 g, FT = 10.8 ± 1.5 g) and impact g's (SG = 8.7 ± 1.4 g, FG = 9.6 ± 1.6 g, ST = 9.9 ± 1.8 g, FT = 10.7 ± 1.1 g) were higher at the faster speed (both $p < 0.001$) and on the track (both $p = 0.001$). **Conclusions:** The RunScribe™ sensors demonstrated face validity by identifying expected changes in spatiotemporal, kinematic, and kinetic measures when participants ran at different speeds and on different surfaces, and appear to be well-suited for use in future studies aimed at answering clinically-oriented sports science and sports medicine questions.

Free Communications, Thematic Poster Presentations: Concussion Policy and Legislation

Thursday, June 29, 2017, 7:30AM-9:00AM, Room 361; Moderator: Jacob Resch, PhD, ATC

Implementation of Concussion Policies in Secondary School Athletics

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Context: Concussion is defined as a brain injury induced by biomechanical forces from direct contact to the head or body resulting in functional disturbances rather than structural injury; unfortunately, concussion is a common injury in athletics, especially collision sports. Appropriate policies for concussion management should include educational opportunities for athletes, coaches, and parents, steps to remove athletes from play with suspected concussion, and a graded return to school and physical activity. However, the adoption of evidence-based concussion guidelines at the secondary school level is currently unknown. **Objective:** To determine the extent of state high school athletics associations (SHSAAs) that require concussion policies that meet current evidence-based minimum best practice recommendations. Additional consideration is given to state legislation if it also enforces these guidelines as well as if guideline adoption had improved from the previous year (2014-2015). **Design:** Descriptive observational study. **Setting:** Secondary school athletics. **Patients or Other Participants:** State High School Athletics Associations. **Data Collection and Analysis:** Nine recommendations for meeting minimum best practices for concussion management were derived from the 2014 NATA position statement on management of sport concussion and the 2012 consensus statement from the 4th International Conference on Concussion in Sport. An extensive review of SHSAA handbooks, constitutions, bylaws, policies and procedures, SHSAA websites, and enacted state legislation was performed for the academic year 2015-2016 to identify the inclusion of the recommendations into mandated policies for the member schools governed by the SHSAA. Frequencies were tabulated for each recommendation and results presented as a representative sample of the United States and District of Columbia. Percent improvement from the 2014-2015 academic year by individual recommendation was also calculated. **Results:** All 51 (100%) SHSAAs require preseason concussion education; a 2% improvement from 2014-2015. All but one SHSAA (98%) require that athletes suspected of having a concussion are not permitted to return to participation the same day and 98% also require a written release from a licensed physician or athletic trainer before return to participation; both recommendations had a 4% improvement from 2014-2015. Forty-four percent of SHSAAs require a graduated return-to-play protocol; a 24% improvement from 2014-2015. Additional data from 2015-2016 included: 16% of SHSAAs require an emergency action plan and concussion referral plan, 6% require certified helmets/equipment, 4% require concussion questions on the pre-participation exam, 4% require a return-to-learn before return-to-play, and 2% require a plan for care of head/cervical spine injuries. **Conclusions:** There are currently no SHSAAs that meet all nine of the evidence-based minimum best practices for concussion management. Despite improvements related to education and removal from activity with suspected concussion, substantial changes still need to be made regarding adherence to best practice recommendations in order to improve athlete health and safety.

Clinical Presentation, Concussion Management and Return-to-Play Practices of Secondary School Athletic Trainers Between 2013-2015

Hixson KM, Williams RM, Johnson RS, Valovich McLeod TC: A.T. Still University, Mesa, AZ

Context: Following the 2012 International conference on concussion in sport, updated concussion management guidelines were implemented to ensure best practices. Despite an increased awareness and better evidence for concussion management, it is largely unknown how athletic trainers (AT) manage sport-related concussions and return to play practices following the updated consensus guidelines. **Objective:** To assess adolescent athlete concussion management and return-to-play (RTP) decision-making as reported by ATs in the secondary school setting between 2013-2015. **Design:** Retrospective medical record analysis. **Setting:** Secondary school athletic training facilities. **Patients or Other Participants:** Medical records from a convenience sample of 107 adolescent athletes (80 males, 10 females, 17 missing, age = 15.86 ± 1.07) participating in interscholastic contact sports, who suffered an AT diagnosed sport-related concussion. **Interventions:** As part of a larger study monitoring concussion recovery, ATs completed a RTP survey describing concussion management and release for participation. The RTP survey captured concussion demographics, total time lost, RTP decisions and criteria, injury classifications, and RTP guidelines used. **Main Outcome Measures:** The dependent variables were the AT completed RTP surveys. Descriptives and frequencies were employed to outline RTP and AT based concussion management patterns. **Results:** Complete medical records were available for 86/107 cases. Immediately following injury, 6 (5.9%) athletes reported loss of consciousness,

10 (10.1%) reported post-traumatic amnesia, 9 (9.2%) reported retrograde amnesia, 6 (6.5%) reported feeling normal after 15 minutes, 12 (14.5%) reported delayed symptom reporting, and most concerning, 2 (2.2%) were RTP the same day of a diagnosed concussion. The RTP decisions were made by the AT in 89.5% (77/86) of cases, team physician in 9.3% (8/86) of cases, and by another physician in 3.5% (3/86) of cases. The RTP criteria most often employed by ATs included, neuropsychological testing performance (92%), symptom checklist (92%), SCAT2 performance (80.5%), player's self-reporting (73.6%), clinical exam findings (64.4%), SAC performance (62.1%), and BESS performance (59.8%). Only 62.7% of diagnosing ATs used an injury classification system for concussion management. Of those who used a classification system, 96.2% (75/82) used the Cantu Evidence Based Guideline. 91.5% (75/82) of diagnosing ATs reported using a RTP guideline; 69.5% (57/82) used the Zurich Progression guidelines, 58.5% (48/82) used the NATA position statement, and 41.4% (34/82) used Cantu guidelines. **Conclusions:** Following concussion, ATs most often make the final RTP decision. These data suggest ATs are following best practices when managing the RTP process. Yet, it is concerning that 2.2% of athletes returned to sport participation the same day as a diagnosed concussion, despite updated evidence suggesting otherwise. Further education and implementation of best practices standards are needed to ensure proper concussion management. Additionally, ATs should work to ensure appropriate RTP decisions are made by a qualified healthcare provider trained in the evaluation and management of concussion.

The Impact of Athletic Trainer Access on School Counselors' Perceptions of Academic Adjustments for Concussed Student-Athletes in the Secondary School Setting

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Context: School counselors (SCs) play an important role in implementing academic adjustments for concussed adolescents and are an important member of the concussion management team. However, little is known about SCs' perceptions of academic adjustments (AA) for student-athletes post-concussion. **Objective:** To compare perceptions of AA between SCs with and without access to an athletic trainer. **Design:** Cross-sectional. **Setting:** Self-reported online survey. **Patients or Other Participants:** 669 SCs (143 males, 390 female, 136 missing; age = 48.8 ± 11.4 years; years of experience = 13.6 ± 9.6 years) across 50 states were recruited from a convenience sample of 8,533 (7.8% response rate). There were 432 SCs with access to an AT (SCw AT) and 113 without access to an AT (SCwo AT; 124 missing). **Interventions:** Participants were solicited via email to complete the Beliefs, Attitudes, and Knowledge of Pediatric Athletes with Concussions Among School Counselors (BAKPAC-SC) survey. The BAKPAC-SC consisted of several 4-point Likert-scale and closed-ended items to explore SCs' perceptions of their role in and current implementation of AA following concussion. **Main Outcome Measures:** Dependent variables were participants' responses to 9 Likert-scale items (ie, higher scores indicated stronger agreement with perceived role in implementing AA) and items regarding AA implementation and personnel involved. Descriptive statistics were calculated to describe perceptions and implementation of AA, while Mann Whitney U ($P < .05$) were used to identify group differences. **Results:** While both SCwAT and SCwoAT strongly agreed that concussions can affect school performance, SCwAT (3.89/4.0 ± .45, $P < .001$) reported significantly higher agreement values than SCwoAT (3.79/4.0 ± .41). Significant differences were also found between SCwAT (3.29/4.0 ± .72, $P = .003$) and SCwoAT (3.06/4.0 ± .74) regarding perceptions that concussions fall under the Americans with Disabilities Act. SCs reported being moderately to extremely familiar (3.56/4.0 ± .68) with AA, but only moderately familiar with 504 plans (3.22/4.0 ± .93) and IEPs (3.45/4.0 ± .72). SCw ATs reported being more familiar with AA (3.65/4.0 ± .58, $P < .001$) and 504 plans (3.28/4.0 ± .90, $P = .014$) than SCwoATs, respectively (3.27/4.0 ± .88; 3.0/4.0 ± 1.06). Most SCs reported recommending AA after a concussion (always 40.2%, $n = 212$; almost always 34.0%, $n = 179$, $P = .023$). 53.2% of SCw AT indicated their school has an academic support team for concussed adolescents, compared to only 28.3% of SCwo AT. Additionally, 87.5% of SCw AT reported having personally encountered a situation where a concussed adolescent experienced a decrease in school and/or academic function compared to 66.4% of SCwo AT. **Conclusions:** These finding suggest that SCs with AT access may be more aware of the need for AA following a concussion. AA following a concussion are an important aspect of concussion management. SCs play an important role in implementing AA, therefore relationships between SCs and ATs should be established to create a more effective academic management team.

Presence of Athletic Trainers, Emergency Action Plans, and Emergency Training at the Time of Sudden Death in Secondary School Athletics

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Context: Current best practices for the prevention of sudden death (SD) during secondary school athletics suggest appropriate on-site medical services (e.g. athletic trainer), venue-specific emergency action plans (vEAP), and basic emergency training for coaches. No comprehensive retrospective analysis of SD cases in this setting has investigated if appropriate on-site medical services were provided, if vEAP were present and followed, or if coaches utilized their emergency training. **Objective:** To examine cases of SD during sport at the secondary school level and describe appropriate medical services, emergency planning, and emergency training at the time of the death. **Design:** Retrospective study. **Setting:** Phone and web-based survey **Patients or Other Participants:** Secondary schools who experienced a sport-related SD during a training or competition session provided by the National Center for Catastrophic Sport Injury Research database from 8/1/2000-7/31/2013. Representatives employed at the time of death or with extensive knowledge of the death were asked to participate. Participants included athletic directors (n = 67), principals (n = 3), coaches (n = 3), athletic trainers (ATs) (n = 2), and one secretary. **Interventions:** Participants responded to a series of survey questions focused on medical services and emergency planning in place at the time of the death. **Main Outcome Measures:** Responses were coded, analyzed, and presented as descriptive statistics (frequency and percentage). **Results:** Of 279 total deaths, 48% (n = 134) of schools responded; 12% (n = 16) refused to participate and 31% (n = 42) had no knowledge of the event. Fifty-seven percent (n = 76) completed the survey. Appropriate medical services (ATs) were not present at 62% (n = 47) of the deaths. No medical services were present at 42% (n = 32) of the deaths. ATs and other medical professionals were present at 38% (n = 29) and 20% (n = 15) of the deaths, respectively. ATs were employed in 61% (n = 46) of the schools, but not present for 37% (n = 17) of the deaths. Where vEAP were in place (66%, n = 50) or where vEAP were in place with an AT employed (n = 34), the EAP was followed 100% (n = 50) of the time. Of cases with (n = 46) and without (n = 30) an AT employed, vEAP were present 74% (n = 34/46) and 53% (n = 16/30) of the time. Of those without a vEAP in place (n = 26), 38% (n = 10/26) continue to remain without a vEAP. Coaches who received emergency training (78%, n = 59), applied their training in 58% (n = 34) of deaths. **Conclusions:** Our findings suggest that 62% of the deaths did not have appropriate on-site athletic training services present. Furthermore, medical services were not present in 42% of SD cases. When vEAP were in place, they were followed. Although medical personnel and vEAP were present in ~60% of cases, the death was not prevented. Detailed case-specific information to identify underlying medical cause of death and opportunities for improving prevention and care procedures are needed.

Assessment of Implementation of the Dylan Steiger's Protection of Youth Athletes Act: A Descriptive Study

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Context: In 2013, the Montana Legislature passed the Dylan Steigers Protection of Youth Athletes Act (DSPYAA) promoting safety for youth athletes stating that any youth athlete who exhibits concussive symptoms must be removed from participation and must be medically cleared to return to play. **Objective:** The purpose of this study was to conduct a statewide evaluation of the implementation of the DSPYAA as well as identify any barriers that prevent implementation. **Design:** Cross-sectional survey. **Setting:** Internet-based study **Patients or Other Participants:** The Implementation of Dylan Steigers Protection of Youth Athletes Act Survey (IDSPYAAS) survey was distributed to superintendents, principals, athletic directors and coaches across Montana (n= 900). 263 surveys were completed for a response rate of 29%. **Interventions:** The IDSPYAAS was developed by the researchers using open and closed ended questions to obtain information on school demographics, concussion policy and educational requirements, as well as any barriers to implementation. A panel of 5 athletic trainers and public health state employees reviewed the survey to establish face and content validity and to provide feedback regarding readability, clarity, and completion time. **Main Outcome Measures:** Quantitative data from the questionnaire was analyzed using Microsoft excel to determine participant demographics, compliance with concussion law, components of concussion law included in school policies, and access to health care providers. Qualitative data analysis was completed using a grounded theory approach that utilized

open, axial, and selective coding procedures to determine barriers that exist for schools to implement a concussion policy as outlined in the DSPYAA. **Results:** Coaches largely made up the responses for this particular survey (51%, n = 127) followed by athletic directors (29%, n = 72). We obtained responses across all enrollment sizes (small and large schools) with a majority of the schools represented teaching K-12 (41%, n = 102). 46 of the 56 counties were represented with responses. 84% (n = 220) of the responding schools report having a concussion policy in place with the required components; however, less than half of the schools reported having access to a school nurse or certified athletic trainer, which was reported as the second largest barrier to fully implementing the law. **Conclusions:** There is a critical need to place athletic trainers and school nurses in Montana schools to provide comprehensive medical care to student athletes. These health care providers can also provide vital support for implementation of the law by facilitating education of parents, athletes, coaches and officials, as well as developing and monitoring return to play and return to learn protocols. More financial and personnel resources are required to help schools fully develop and implement concussion policy. Specifically, it seems that time to educate parents, athletes and coaches is a significant barrier as well as completing the required documentation.

An Examination of Concussion Legislation in the United States

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Context: Athletic trainers are often the first line of defense in the recognition, diagnosis and management of sport-related concussions. There is legislation in each of the United States designed to protect children, primarily those who participate in sports, from the risks associated with concussion. **Objective:** Examine sport concussion policy in the United States and identify limitations of such policies. Three questions guided this study: 1) what does each state's concussion legislation require, 2) who is the population of focus for this legislation, and 3) whom is responsible for delivering those services? **Design:** Qualitative study **Setting:** Government **Patients or Other Participants:** The concussion policies of all 50 states and the District of Columbia were included in our analysis. **Data Collection and Analysis:** An Internet search using the following key words "concussion" and "policy or legislation or law" crossed with each state's name was conducted to identify each policy. We used a content analysis approach to guide our findings and descriptive statistics to determine the number of states requiring each criterion. Peer review and an audit trail were used to establish trustworthiness. **Results:** The analysis revealed four common factors of concussion legislation: 1) affected entities, 2) stipulations for concussion awareness/education, 3) requirements for removal/return to play, and 4) requirements for return to the classroom. Approximately ½ (N = 25, 49%) of the mandates apply only to students enrolled in public schools. Therefore, students enrolled in private schools, including charter schools in many instances, are not protected by these policies. Neither are athletes participating in youth sports, recreational leagues and/or club sports. Only 29% (N = 15) policies are inclusive to public, private, and youth sports organizations. Most states do not specify who is responsible for delivering these services. **Conclusions:** There is significant variance between each state's law and not all children are protected equally. Given this variety, it is important athletic trainers are aware of the limitations of each state's legislation and prepared to advocate on behalf of their patient population. Athletic trainers are in the unique position to advocate for stronger protection of underrepresented populations. Furthermore, it is important for the athletic trainer to remember concussion policies are a minimum standard and when available, best practices should be followed.

Bilateral Lower Extremity Energy Absorption Patterns and Muscle Strength in Adolescent Males and Females During Jump-Landing at Return to Sport Following Anterior Cruciate Ligament Reconstruction

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Context: Asymmetries of the lower extremity muscle strength and biomechanics have been identified in individuals following anterior cruciate ligament reconstruction (ACL-R), which could contribute to recurrent anterior cruciate ligament (ACL) injury. Deficits in the ability to absorb forces through the lower extremity increases strain in the ACL, which could potentially lead to ACL injury. It is unclear if asymmetries in energy absorption (EA) patterns of the lower extremity exist in adolescents following ACL-R. **Objective:** To examine the lower extremity energy absorption pattern differences between the ACL-R and uninvolved limbs in adolescent males and females. **Design:** Cross-sectional descriptive. **Setting:** Clinical Research Laboratory. **Patients or Other Participants:** A total of forty-three participants with unilateral ACL-R who were at a time of return to sports (RTS) following ACL-R volunteered (Male: N = 20, Age = 15.6 ± 1.2 yrs, Ht = 177.3 ± 7.7 cm, Mass = 76.4 ± 15.9 Kg; Female: N = 23, Age = 15.1 yrs, Ht = 165.2 ± 6.7 cm, Mass = 65.8 ± 12.1 Kg). **Interventions:** Joint net power was assessed using an eight-camera infrared optical motion capture system and two force plates while participants performed three separate jump-landing (JL) tasks by jumping off a 30cm box set at a distance of 50% of their height from the force plates followed by immediate vertical jump. Isokinetic strength of the quadriceps and hamstrings at 60 deg/sec was collected using an isokinetic dynamometer. All data were assessed bilaterally. **Main Outcome Measures:** EA of the hip, knee, and ankle joints were calculated by integrating the negative portion of the power curves during the loading phase of the JL task, normalized to the product of height and weight and averaged across three trials. Total EA was calculated as a sum of each joint EA. Peak torque of the quadriceps and hamstrings were normalized to body weight and averaged across five trials. Separate paired t-test were performed to examine the difference between the ACL-R and contralateral limbs in each group ($\alpha \leq 0.05$). **Results:** For both males and females, the ACL-R limb had significantly decreased total EA compared to the contralateral limb (Male: ACL-R = -0.22 ± 0.7, CON = -0.27 ± 0.9, $p = 0.01$; Female: ACL-R = -0.22 ± 0.7, CON = -0.27 ± 0.6, $p = 0.007$). Males demonstrated significantly decreased quadriceps strength (ACL-R = 1.76 ± 0.4, CON = 2.49 ± 0.5, $p < 0.001$), hamstrings strength (ACL-R = 1.05 ± 0.3, CON = 1.14 ± 0.2, $p = 0.03$), and EA at the knee joint (ACL-R = -0.05 ± 0.0, CON = -0.09 ± 0.1, $p = 0.033$) in the ACL-R limb compared to the contralateral limb. Females demonstrated significantly decreased quadriceps strength (ACL-R = 1.22 ± 0.3, CON = 1.76 ± 0.3, $p < 0.01$) and increased EA at the ankle joint (ACL-R = -0.04 ± 0.0, CON = -0.06 ± 0.0, $p = 0.008$) in the ACL-R limb compared to the contralateral limb. No other significant differences were observed. **Conclusions:** Both groups demonstrated reduced ability to absorb energy on the ACL-R limb. Adolescent males avoided the use of the knee joint while adolescent females used more ankle joint to absorb energy. Altered muscle strength following ACL-R may contribute to these altered EA strategies.

Comparison of Quadriceps Rate of Torque Development and Sagittal Plane Knee Kinematics During Two Jump Tasks Between ACL Reconstructed and Healthy Females

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Context: Emerging evidence suggests that explosive strength of the quadriceps, quantified as the rate of torque development (RTD), is associated with sagittal plane knee kinematics related to ACL injury risk. Initial work from our laboratory indicates that healthy females with lesser quadriceps RTD land with lesser knee flexion angle at initial contact (KFIC). It has also been shown that ACL reconstructed (ACLR) patients with quadriceps RTD deficits exhibited lesser knee flexion excursion (KFE) during treadmill running. However, no previous study has compared quadriceps RTD and sagittal plane knee kinematics between ACLR and healthy females during activities. **Objective:** To compare quadriceps RTD and sagittal plane knee kinematics during single-leg jump cuts (SLJC) and double-leg jump landings (DLJL) between the involved limb of ACLR and non-dominant limb of healthy females. **Design:** Cross-sectional. **Setting:** Research laboratory. **Patients or Other Participants:** Eighteen ACLR (Age: 9.9 ± 1.23 years, Height: 165.1 ± 6.4 cm, Mass: 63.8 ± 10.9 kg, Time after surgery: 35.1 ± 13.7 months) and twelve healthy (Age: 21 ± 2.6 years, Height: 163.5 ± 7.7 cm, Mass: 57.3 ± 6.5 kg) recreationally active female volunteers. **Interventions:** Isometric quadriceps torque-time curves were collected using a Biodex System 3 dynamometer during three trials in which participants attempted to extend the knee as hard and fast as possible. Lower extremity

biomechanics were assessed via an optical motion capture system interfaced with two force plates as participants completed three SLJC and three DLJL trials. **Main Outcome Measures:** RTD was calculated by fitting a line of best fit to the recorded torque-time curve between torque onset and 50 ms after onset and normalized by body mass. The trial with the maximum RTD was used for analysis. KFIC and KFE were identified and averaged across trials. KFE was calculated by subtracting peak knee flexion from KFIC. Mean differences between groups for each outcome measure were assessed using independent t-tests ($\alpha \leq 0.05$). **Results:** Quadriceps RTD was not significantly different between ACLR (10.09 ± 4.24 Nm/s/kg) and healthy (9.95 ± 4.52 Nm/s/kg) females ($p = 0.931$). No significant differences in knee kinematics were identified between groups during SLJC (KFIC- ACLR: 23 ± 6.1° vs. Healthy: 21.9 ± 5.8°, $p = 0.640$; KFE- ACLR: 36.8 ± 7.2° vs. Healthy: 39 ± 6.1°, $p = 0.382$), and DLJL (KFIC- ACLR: 14.9 ± 4.4° vs. Healthy: 17.4 ± 6.6°, $p = 0.232$; KFE- ACLR: 75.3 ± 6.1° vs. Healthy: 70 ± 9.5° degree, $p = 0.073$). **Conclusions:** ACLR females with similar quadriceps RTD as healthy females did not exhibit differences in sagittal plane knee kinematics that would be associated with greater risk of ACL injury. The results suggest that restoring normal quadriceps RTD after ACL reconstruction may be important for facilitating the use of sagittal plane knee kinematics during functional tasks that might be related to reduced risk of re-injury. Future studies should evaluate if ACLR patients with similar quadriceps RTD as healthy individuals also demonstrate lesser risk of re-injury.

Sagittal Plane Knee Mechanics in Those Who Pass or Fail a Functional Test Battery

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Context: A Functional Test Battery (FTB) has been proposed to determine the readiness of patients for full activity following ACL reconstruction (ACLR). However, the knee joint landing biomechanics of ACLR patients who have passed (ACLR-Pass) or failed (ACLR-Fail) a FTB before and after exercise have not been investigated. Thus, it is difficult to assess the usefulness of the FTB when making return to activity decisions. **Objective:** To compare knee joint biomechanics between ACLR-Pass, ACLR-Fail, and healthy females before and after exercise. **Design:** Cross-sectional. **Setting:** Research laboratory. **Patients or Other Participants:** Thirty recreationally active females: Ten ACLR-Pass (19.8 ± 1.0 years, 165.0 ± 0.6 cm, 60.3 ± 9.9 kg, Time after surgery: 36.1 ± 12.6 months), eight ACLR-Fail (20.0 ± 1.5 years, 165.0 ± 0.3 cm, 68.3 ± 11.2 kg, Time after surgery: 34.0 ± 14.7 months), and twelve healthy females (21 ± 2.6 years, 163.5 ± 7.7 cm, 57.3 ± 6.5 kg). **Interventions:** All participants completed a FTB consisting of two subjective assessments of knee function, quadriceps maximum voluntary isometric contraction, and four single-leg hop tests; and double-leg jump landing (DLJL) and single-leg jump cutting (SLJC) while 3D kinematic and kinetic data were collected, pre-and post-exercise (exercise included treadmill walking and jumping). ACLR patients were divided into pass (pass all tests) or fail (fail at least one of all tests) from the results of the FTB. **Main Outcome Measures:** Knee biomechanics on reconstructed limb of ACLR females and non-dominant limb of healthy females was collected. Knee flexion angle at initial contact (KFIC), and peak knee flexion angle (PKF) were identified. Internal peak knee extension moment (PKEM), and peak anterior tibial shear force between initial contact and PKF were calculated using inverse dynamics procedures. Differences between ACLR-Pass, ACLR-Fail, and healthy before and after exercise were assessed using a mixed-model ANOVAs ($p \leq 0.05$). **Results:** During DLJL, there was a significant main effect of exercise with lesser KFIC after exercise, $F(1,27) = 9.03$, $p = 0.006$, $\eta p2 = 0.251$ (Pre-exercise: 15.9 ± 5.4°, Post-exercise: 14.4 ± 5.6°). During SLJC, there was a significant group by time interaction effect for PKF with lesser PKF in healthy females after exercise, $F(1,27) = 5.87$, $p = 0.031$, $\eta p2 = 0.227$ (Pre-exercise: ACLR-Pass: 60.3 ± 4.4°, ACLR-Fail: 59.1 ± 5.9°, Healthy: 61.0 ± 4.0°; Post-exercise: ACLR-Pass: 60.6 ± 5.5°, ACLR-Fail: 60.3±7.1°, Healthy: 58.5 ± 4.7°) and main effect of exercise identified with smaller PKEM after exercise, $F(1,27) = 5.87$, $p = 0.022$, $\eta p2 = 0.179$ (Pre-exercise: -0.33 ± 0.09 N*m x [N*m]-1, Post-exercise: -0.32 ± 0.09 N*m x [N*m]-1). **Conclusions:** A significant interaction effect for PKF during SLJC resulted from the PKF reduction only in healthy females after exercise. While failing a FTB should represent limited ability of lower extremity function that potentially leads to movement pattern indicating a greater risk of re-injury, there were no differences in ACLR knee biomechanics during DLJL and SLJC performed before and after exercise between ACLR-Pass and ACLR-Fail. The results suggest that the FTB is likely not useful for identifying ACLR females that use high-risk movement mechanics in their ACLR limb despite having returned to full physical activity.

Patients With Anterior Cruciate Ligament Reconstructive Surgery Demonstrate Reduced Ability to Contract Transverse Abdominis But No Difference in Balance

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Context: Patients who have undergone anterior cruciate ligament reconstructive surgery (ACLR) display altered lower extremity biomechanics compared to those who have never suffered an ACL injury. Poor trunk stability during dynamic activities has been shown to contribute to altered lower extremity kinematics, thus possibly increasing the risk of ACL re-injury in these patients. It is suggested that appropriate function of the transverse abdominis (TrA) establishes optimal neuromuscular control of the trunk during lower extremity movement; however, the effect the transverse abdominis has on trunk stability during activity in patients with ACLR is still unknown. **Objective:** The purpose of this study was to compare TrA contraction ratio and postural control during single leg balance in participants with and without ACLR. **Design:** Cross-sectional design. **Setting:** Research laboratory. **Patients or Other Participants:** 14 participants, 7 with self-reported ACLR (Age = 23.1 ± 3.4 years, Height = 181.2 ± 11.1 cm, Mass = 88.5 ± 13.4 kg) and 7 healthy controls (Age = 24.2 ± 5.3 years, Height = 175.9 ± 1.9 cm, Mass = 83.5 ± 7.1 kg) participated in this study. **Interventions:** Postural control during single leg balance was measured using the Biodex SD Balance System. The injured leg was assessed for the ACLR group and the dominant leg was assessed for the control group. Transverse abdominis thickness was measured from the inside border of the fascia outline using diagnostic ultrasound. **Main Outcome Measures:** Resting TrA thickness, TrA contraction thickness during abdominal hollowing, and TrA thickness changes in the supine lying position and stability index during single leg balance were measured and averaged across trials. Independent sample t-tests were used to compare group differences in TrA contraction ratio and single leg balance; a priori alpha level of 0.05. **Results:** We observed a significant difference in TrA contraction ratio ($t(12) = 2.50$, $p = 0.03$), between groups, as the ACLR group demonstrated reduced ability to contract the TrA (1.46 ± 0.10) as compared to the control group (1.67 ± 0.86). There was, however, no difference in postural control during the single leg balance between the ACLR group (1.8° ± 0.76°) and control group (2.1° ± 0.86°). **Conclusions:** We observed a significant difference in TrA contraction ratio between the two groups, indicating our sample of patients with ACLR were unable to contract their TrA as well as those who never suffered an ACL injury. We did not observe any difference in postural control, indicating that TrA contraction – though impaired – may not affect a patient's ability to maintain balance. Future research should explore whether deficits in TrA contraction affect other aspects of movement and clinical outcomes in patients with ACLR.

Comparisons of ACL Laxity, Size and Intrinsic Properties Between ACLR and Healthy Individuals

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Context: While joint laxity has been reported as a risk factor of ACL injury, there is evidence suggesting that the size and composition of the ligament may impact ACL injury risk, but less is known. Given the relative high risk of second ACL injury in the ACL-reconstruction (ACLR) population, in-vivo comparisons in intrinsic ACL characteristics between ACLR and healthy populations may offer insight to ACL injury risk. **Objective:** To examine in-vivo ACL morphometric characteristics, ACL structural composition, femoral notch width, and anterior knee laxity (AKL) between ACLR and healthy individuals. **Design:** Cross-sectional. **Setting:** Controlled laboratory. **Patients or Other Participants:** Eleven recreationally-active females (1.65 ± .08 m, 58.6 ± 5.0 kg, 20.6 ± 1.4 yrs) and ten recreationally-active unilateral ACL reconstruction females (1.70 ± .05 m, 67.5 ± 7.0 kg, 21.9 ± 2.7 yrs) were recruited to have similar activity levels. **Interventions:** Structural T1 and T2 structural imaging and T2 and T2* relaxation time MRI sequence were performed on the healthy individuals' left knee while the uninjured limb of the ACLR population was examined. AKL was obtained via a commercial joint arthrometer. **Main Outcome Measures:** ACL volume, cross sectional area (CSA) and width measures were obtained from T2 weighted data. Femoral notch width and notch width index (NWI) were measured from T1 weighted images. T2 and T2* ACL relaxation times were measured using 5 spin echo sets and 12gradient

echo sets, respectively. AKL was measured at 130N of applied anterior tibial force using a commercial arthrometer. Independent sample T-tests examined differences in all morphometry measures between healthy and ACLR participants. **Results:** The ACL group had a smaller NWI (0.22 ± 0.02 Vs 0.25 ± 0.01, p = .004, ES = 1.41) and lesser ACL width (6.1 ± 1.0 mm Vs 7.2 ± 1.3 mm, p = .052, ES = 0.91) than healthy individuals. There were no significant differences in AKL (8.7 ± 1.8 mm Vs 8.0 ± 2.8 mm, p = .480, ES = 0.32) ACL volume (1012.8 ± 175.5 mm3 Vs 1151.1 ± 258.7 mm3, p = .172, ES = 0.63), CSA (0.7 ± 0.2 cm2 Vs 0.7 ± 0.2 cm2, p = .878, ES = 0.07), T2 (50.3 ± 9.2 ms Vs 54.4 ± 8.2 ms, p = .298, ES = 0.47) and T2* ACL relaxation times (19.1 ± 2.4 ms Vs 18.4 ± 1.7 ms, p = .445, ES = 0.34) between ACLR and healthy individuals, respectively. **Conclusions:** ACLR individuals had smaller ACL size and a narrower femoral notch size than healthy individuals. These findings suggest that ACL and notch size should be considered when investigation of the ACL injury risk factors. Effect sizes suggest that there may be differences ACL relaxation times in a fully power study. Future work on comprehensive imaging techniques to understand specific ligamentous properties is warranted.

Comparison of Aerobic Capacity in Healthy and Surgically Repaired Anterior Cruciate Ligament Legs in Recreationally Active Individuals

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Context: Traditional clinical measures have been used to measure strength, agility, and balance following anterior cruciate ligament surgery (ACLS). However, no known clinical measures have examined single-leg aerobic capacity differences. **Objective:** To determine the differences in aerobic capacity in the uninjured legs and surgical legs in those having had ACLS and to compare those differences to the non-ACL surgery control group. **Design:** Controlled laboratory study. **Setting:** University research laboratory. **Patients or Other Participants:** Eight ACLS individuals (5 females, 3 females; 23 ± 4 yrs; 167.2 ± 11.9 cm; 75.4 ± 15.6 kg; months since clearance = 12.9 ± 3.6) and 8 matched healthy controls (con) by age, gender, and sport (5 females, 3 males; 24 ± 3.5 yrs; 169.7 ± 9.4 cm; 72.3 ± 17.3 kg;) volunteered. **Interventions:** Participants performed the novel single-leg cycling maximum oxygen consumption (V02 max) test measuring aerobic capacity on a counterweighted electromagnetically braked Velotron cycle ergometer. The counterweighted contralateral pedal assisted the upward motion during pedaling and helped to maintain normal cycling mechanics during the VO2 max test. During this test, expired gas was analyzed with a metabolic cart to determine the volume of oxygen consumed and carbon dioxide produced. Each leg was tested on a separate visit at least 72 hours apart. **Main Outcome Measures:** Single-leg cycling aerobic capacity outcome measures included VO2 max, ventilatory threshold, heart rate, rate of perceived exertion, maximum watts cycled, cycling end time and time to fatigue during VO2 max. A 2x2 repeated measures ANOVAs was performed with the independent variables: group (con, ACLS) and leg (injured, uninjured) to observe interactions. Paired samples t-tests were performed. Separate dependent t-tests were run to observe differences between leg (injured, uninjured) in subjects in the ACL group. All data was analyzed using IBM SPSS Statistics Version 24 (Armonk, NY). For all analysis alpha was set a priori (P = 0.05). **Results:** There were significant interactions in maximum watts cycled (ACL = 127.0 ± 23.9 watts, con = 128.6 ± 31.2 watts, P = 0.006), and time to fatigue in VO2 peak (ACL = 13.4 ± 2.3 min, con = 12.2 ± 2.6 min, P = 0.028) within the con and ACLS groups. No interaction was found with aerobic capacity (ACL = 30.2 ± 8.0 ml/kg/min, con = 31.6 ± 7.3 ml/kg/min, P = 0.319) within the con and ACLS groups. **Conclusions:** Based on the research conducted, further investigation is warranted on the statistically significant interactions in maximum watts cycled and time to fatigue in VO2 peak and whether single leg cycling could be a good clinical measurement if evaluated during rehabilitation or as a clinical measure.

Relationships of Muscle Function and Subjective Knee Function in Chronic ACL-Reconstructed Patients

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Context: Within chronic anterior cruciate ligament reconstructed (ACLR) patients, objective measure guidelines have been found to improve subjective function in a broad population of patients. Examining relationships between muscle function and subjective knee function at different time frames post-surgery may individualize treatment measures and improve outcomes post-ALCR. **Objective:** To examine the associations between subjective knee function and lower extremity muscle strength and hopping performance in ACLR patients at sequential timeframes post-surgery. **Design:** Descriptive. **Setting:** Laboratory. **Patients or Other Participants:** A total of 53 participants with primary, unilateral ACLR participated in this study. Cohorts were created from time since ACLR: early group $\leq$ 2 years, middle group = 2-5 years, late group $\geq$ 5 years. The cohorts were composed of 17 individuals in the early group (age = 21.8 ± 4.2 years, height = 171.2 ± 12.3 cm, mass = 68.6 ± 16.0 kg, time post-surgery = 17.1 ± 5.5 months), 19 individuals in the middle group (age = 20.2 ± 1.5 years, height = 173.2 ± 8.8 cm, weight = 68.9 ± 10.0 kg, time post-surgery = 39.9 ± 7.4 months), and 17 individuals in the late group (age = 26.7 ± 4.5 years, height = 173.6 ± 9.9 cm, weight = 69.6 ± 13.1 kg, time post-surgery = 103.1 ± 34.0 months). **Interventions:** None. **Main Outcome Measures:** Subjective knee function quantified by the International Knee Documentation Committee (IKDC) and Knee Osteoarthritis Outcome Score (KOOS). Isometric knee extension and flexion strength at 90 degrees/second. Single-leg hopping performance measured by single hop, triple hop, crossover hop, and 6-m timed hop. We calculated correlation coefficients (r) between subjective measures of knee function and measures of muscle strength and jumping performance. Alpha level was 0.05 or less. **Results:** The early group had a moderate, positive correlation between involved limb flexion power and IKDC (r = .458, p = .032), and a moderate, positive correlation between involved limb flexion power and KOOS (r = .427, p = 0.44). The middle group had a moderate, negative correlation between cross hop symmetry and IKDC (r = -.469, p = .021), a moderate, positive correlation between extension peak torque symmetry and KOOS (r = .438, p = .030), a moderate, positive correlation between extension work symmetry and KOOS (r = .494, p = .016), and a moderate, positive correlation between the 6-m timed hop and KOOS (r = .635, p = .002). The late group had a moderate, positive correlation between flexion power symmetry and IKDC (r = .617, p = .004), a strong, positive correlation between the 6-m timed hop symmetry and IKDC (r = .716, p = .001), a moderate, positive correlation between extension work symmetry and KOOS (r = .414, p = .045), a moderate, positive correlation between flexion power symmetry and KOOS (r = .527, p = .012), and a strong, positive correlation between the 6-m timed hop symmetry and KOOS (r = .746, p = .001). **Conclusions:** ACLR patients less than two years following surgery possess stronger relationships between involved limb strength measures and subjective function. Patients in the late group had higher correlation between hopping symmetry measures and subjective function. Future clinical guidelines to improve subjective function for chronic ACLR patients may need to consider time since surgery as a potential factor.

Physical Activity Influences the Relationship Between Lower Extremity Function and Fear of Movement After ACL Reconstruction

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Context: Anterior cruciate ligament injury and reconstruction (ACL-R) remains common among individuals participating in sport. Psychological factors, such as increased kinesiophobia (fear of movement), have been identified in patients after ACL-R. The relationship between kinesiophobia and impairment-based outcomes is not well understood and it is unclear how activity level mediates this relationship. **Objective:** To determine how physical activity influences the relationship between lower extremity function and kinesiophobia at the time of physician clearance after ACL-R. **Design:** Cross-sectional. **Setting:** Laboratory. **Patients or Other Participants:** 80 patients with a primary, unilateral ACL-R (38 female/ 42 male; age = 21.7 ± 7.8 years; height = 173.3 ± 9.4 cm; mass = 75.1 ± 17.2 kg; time from surgery = 6.3 ± 1.0 months) and 80 healthy controls (43 female/ 37 male; age = 22.1 ± 4.1 years; height = 172.7 ± 11.3 cm; mass = 70.6 ± 11.3 kg) volunteered for this study. **Interventions:** None. **Main Outcome Measures:** Quadriceps function was measured by isokinetic peak torque, total work, and average power at 90°/second, and maximal voluntary isometric contraction (MVIC) torque at 90° knee flexion in the involved limb. Force measures were normalized to body mass. Functional performance was measured by 4 single-limb hop tasks: single, triple, crossover, and 6-meter timed hop, and normalized to height. The Godin Leisure-Time Exercise Questionnaire and Tampa Scale of Kinesiophobia were used to measure physical activity and fear of movement. Bivariate Pearson's r correlations were used to examine the relationships between quadriceps strength, functional performance, and

activity level with fear of movement. Correlations were calculated for the total ACL-R sample, and separately for patients with high and low activity level. **Results:** ACL-R patients demonstrated reduced quadriceps function, functional performance, and patient-reported function compared to healthy controls ($p < .05$). Among all ACL-R patients, the single hop ($r = -.286$), triple hop ($r = -.323$), crossover hop ($r = -.331$), and Godin ($r = -.312$) were correlated with kinesiophobia. Patients with high activity level demonstrated less kinesiophobia (31.0 ± 5.6 vs. 34.5 ± 6.5, $p = .043$) compared to those with low activity, but did not differ by quadriceps function or functional performance (all $p > .05$). Weak to moderate correlations were observed between peak isokinetic torque ($r = -.398$), average isokinetic power ($r = -.438$), single hop ($r = -.468$), triple hop ($r = -.521$), crossover hop ($r = -.544$) and kinesiophobia among patients with high activity levels only. No measures of quadriceps function or functional performance were correlated with kinesiophobia in patients with low activity levels. **Conclusions:** Single hop performance and physical activity level are inversely related to fear of movement. Physical activity level does appear to mediate the relationship between such factors and fear of movement. In patients with low activity levels, traditional impairment-based measures are not related to fear of movement.

Periacetabular Osteotomy for Hip Dysplasia In A Division I Female Water Polo Athlete: A Case Report

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Background: A 22 year-old NCAA Division I female water polo player, with no prior history of hip injury and no signs of developmental dysplasia of the hip (DDH), reported to athletic training facility early December 2014 complaining of right hip pain after stationary bike workout. She reported hearing and feeling a sudden "pop" within the right hip with immediate hip pain when she was pedaling at moderate intensity of a stationary bike. Numbness and tingling was felt initially with the mechanism. Tender to palpate at right hip flexor and anterior hip joint, as well as greater trochanter. Her chief complaints were pain with walking and prolonged sitting. Antalgic gait noticed during evaluation. AROM was decreased significantly, specifically hip flexion (< 45°), abduction, and external rotation, all limited by pain. PROM was limited in flexion and abduction with pain. Manual muscle testing revealed hip abduction and flexion strength was 4/5 with pain, and 4/5 hip internal and external rotation without pain. Positive FADDIR, FABER, Ely's and Kendall's tests, negative Thomas' test. **Differential Diagnosis:** Acetabular labrum tears, femoral acetabular impingement syndrome, ligamentum teres sprain, hip joint subluxation. **Treatment:** She was referred to the team physician for follow-up. X-ray and MRI images showed no avascular necrosis or fracture. The center edge angle (Wiberg angle) was borderline shallow 22° on right side and a tear along the base of the anterior labrum with shallow detachment. There was mild osseous ridging along the anterior femoral head-neck junction and no acetabular retroversion found. No soft tissue calcification, bursa collection or focal soft tissue edema were found. An abnormal alpha angle found and no bursitis or tendonitis were shown. In July 2015, periacetabular osteotomy (PAO) was performed to rotate the acetabular fragment into optimal position and fixed to the pelvis with three screws. Initially up to 5 weeks, her post-surgical rehabilitation focused on pain and edema control, toe-touch and partial weight-bearing with crutches, and restoring hip ROM. Strengthening exercises were performed with limitations to prevent re-injury: hip flexion up to 90°, internal and external hip rotation up to 20°. Exercises included assisted manual ROMs, isometric strengthening of the hip and quadriceps, and postural balance control with crutches. She was able to walk in water and perform moderate aquatic exercises to help to restore ROMs. From 5 to 10 weeks, she focused on restoring full hip ROMs and strength exercises (lunges, leg press, deadlifts, mini squats) back to pre-injury status. An additional focus of the rehabilitation was performing proper gait with progression from, partial to full weight bearing activities. She was able to return to ADLs after 12 weeks. After 12 weeks, exercises emphasized core strength, lower extremity strength, proprioception, proper walking and running gait without compensation, and sport specific exercises. At 24 weeks, she was able to fully participate in sports without limitations. **Uniqueness:** She was asymptomatic prior to injury. Upon further examination and diagnostic imaging, discovered borderline DDH on right side. Shallow detachment of the anterior labrum from the acetabulum also associated with injury. Hip dysplasia was not originally suspected. **Conclusions:** This case describes the rehabilitation program employed following PAO for an atypical case of DDH in a water polo athlete who had no signs and symptoms of DDH prior to sports participation. Despite her level of injury, the athlete was medically cleared to participate in her sport in season. At the end of her season, the athlete opted to undergo PAO given the risks and underwent a 6-month rehabilitation before a full return to function. This case report aides with treatment knowledge and post-surgical rehabilitation techniques for athletic trainers.

Calculation of Resistive Loads for Elastic Resistive Hip Exercises

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Context: What is the correct resistive load to start exercise training with elastic resistance (ER) to gain strength? This question is typically answered by the clinician's best estimate and patient's level of discomfort. The isotonic literature is clear to start exercise at 50% of a 1 repetition maximum (RM). However, in a clinical setting it is more likely to have an isometric assessment of strength not a 1 RM. **Objective:** To determine the average level of ER an individual starts with that gains strength when performing hip strengthening exercises following isometric strength testing. **Design:** Pre-test/post-test clinical trial. **Setting:** Clinical. **Patients or Other Participants:** Thirty-seven healthy subjects (31 ± 13 yrs, 73 ± 17 kg, 170 ± 12 cm) volunteered. **Interventions:** To determine starting load for ER, three critical components had to be captured; amount of "force produced", "force distance" which is the distance from center of rotation to location where force was produced, and "exercise distance" which is the distance from center of rotation to the location where exercise resistance would be applied. Participant's isometric strength was measured with a dynamometer (BTE Primus, Hanover, MD). Isometric hip abduction and hip extension force in Newtons was averaged from two trials. The "force distance" was measured from greater trochanter to femoral lateral epicondyle in meters to represent the location where the dynamometer pads were placed during strength testing. Elastic resistance hip abduction and extension was performed with band around ankle. The "exercise distance" was measured in meters between greater trochanter to lateral malleolus. The force produced was converted to torque and the exercise force was calculated with the following equations. 1) Force Produced (N) x Force Distance (m) = Test torque (Nm). 2) Test Torque (Nm) /Exercise Distance (m) = Exercise load (N) /4.45 to convert to pounds of forces. The Exercise load was presented to the participant as 15%, 20%, 25%, 30%, 40%, and 50% using a load cell (Smart Handle, Patterson Medical Supply, Chicago, IL) attached to the ER. The participants performed standing hip abduction and extension exercises for three sets of 10 repetitions with good form and strength re-tested at the end of 8 weeks. **Main Outcome Measures:** The fraction of maximal load calculated for the exercise was recorded for each exercise and torque produced was normalized to body weight (BW). **Results:** The average percentage of maximal isometric force that was used to initiate exercises was 30 ± 7% BW for hip exercises. The average strength gain for the 8 weeks was 11.5 ± 6.4% BW. **Conclusions:** This provides clinicians with a reasonable yet specific target force to start ER training. Individual variations will occur but utilization of a load cell during ER provides objective documentation of exercise progression. Isometric strength measures do not transfer to an isotonic exercise recommendation of 50% of a 1RM.

Influence of Isokinetic Hip Strength Measures on Landing Biomechanics During Double and Single Leg Landings

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Context: Decreased hip strength has been suggested to contribute to landing biomechanics that increase the risk of ACL injuries. However, the relationship between hip strength and landing biomechanics is conflicting. Previous studies are limited to examining the peak torque produced during isometric or isokinetic assessments of hip strength, particularly during concentric contractions. It is possible that isokinetic torque production of the hip through a range of motion, both concentrically and eccentrically, may help clarify the role of hip strength in landing biomechanics. Furthermore, it is unknown whether a relationship exists across double and single leg landing tasks. **Objective:** To determine the influence of hip strength measures on lower extremity biomechanics during a double and single-leg landing task. **Design:** Descriptive laboratory study. **Setting:** Research laboratory. **Patients or Other Participants:** Twenty female Division I collegiate soccer athletes (19.2 ± 0.93 yrs, 167.2 ± 5.7 cm, 65.9 ± 6.6 kg) volunteered. **Interventions:** Using an isokinetic dynamometer, 5 repetitions of isokinetic concentric (CON) and eccentric (ECC) hip extension (HEXT) torque were measured at 60 deg·s-1 on the left limb. Three-dimensional hip and knee kinematics and kinetics were assessed using a three-dimensional motion analysis system during three trials of a drop vertical jump (DVJ) from a 31cm box and a single leg hop (SLH) over a hurdle (height = 12.7 cm) set 40% of the subject's height from a force plate. **Main Outcome Measures:** The average work per repetition (J) and peak torque (Nm) of the middle 3 trials for CON and ECC HEXT strength measures, peak external

joint moments (Nm) during the deceleration phase [from initial contact to lowest vertical center of mass] of the DVJ and SLH normalized to body weight (BWHT), and hip and knee joint motion were used for analyses. **Results:** During the DVJ, greater peak CON HEXT (1.55 ± 0.19 Nm·BWHT-1) predicted less frontal plane hip motion (6.61 ± 2.88°, R2 = 0.265, P = 0.024), while greater CON HEXT work (0.88 ± 0.18 J·BWHT-1) predicted greater frontal plane knee motion (6.49 ± 1.51°, R2 = 0.421, P = 0.003). Greater ECC HEXT work (0.98 ± 0.32 J·BWHT-1) predicted greater hip adduction moment (0.16 ± 0.11 Nm·BWHT-1, R2 = 0.335, P = 0.009). During the SLH, greater ECC HEXT work predicted greater hip internal rotation moment (-0.02 ± 0.04 Nm·BWHT-1, R2 = 0.206, P = 0.050). Hip strength was not predictive of any other kinetic and kinematic variables in either task (P > 0.05). **Conclusions:** Greater CON HEXT strength predicted greater frontal plane knee motion but less hip motion during a double-leg landing task. Greater ECC HEXT strength predicted greater frontal and transverse plane hip moments during a double and single-leg landing task, respectively. Intervention programs aimed at controlling lower extremity motion and modulation of joint forces during landings should consider strategies to focus on both CON and ECC strengthening of the hip extensors.

Influence of Hip Strength and Activation on Lower Extremity Landing Biomechanics in Female Soccer Players

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Context: The influence of hip strength on dynamic movement patterns that increase risk of knee injuries remains unclear, potentially because hip muscle activation has not been accounted for in previous studies. Understanding the influence of hip strength and activation in lower extremity landing biomechanics may help in developing more effective interventions to reduce risk of knee injuries. **Objective:** To determine if the inclusion of hip muscle activation strengthens the relationship between hip strength and landing biomechanics. **Design:** Descriptive laboratory study. **Setting:** Research laboratory. **Patients or Other Participants:** Twenty female division 1 collegiate soccer athletes (19.2 ± 0.93 yrs, 167.2 ± 5.7 cm, 65.9 ± 6.6 kg) volunteered. **Interventions:** Five repetitions of concentric (CON) and eccentric (ECC) hip extension (HEXT) strength of the left limb were collected using an isokinetic dynamometer at 60 deg•s-1. Three-dimensional hip and knee kinematics and kinetics were assessed using a motion analysis system and activation of the gluteus medius (GMED) and gluteus maximus (GMAX) was assessed using surface electromyography (sEMG) during three drop vertical jumps (DVJ) from a 31cm box. **Main Outcome Measures:** The average work (J) per repetition (torque produced across a 90-30° range of motion) of the middle 3 repetitions for HEXT, peak external joint moments (Nm) during the deceleration phase [from initial contact to lowest vertical center of mass] of the DVJ normalized to body weight (BWHT), and hip and knee joint motion were used for analyses. The average root mean square amplitude (RMS) of the sEMG signal of the GMED and GMAX 150ms prior to (PRE) and following (POST) initial contact was normalized to the peak RMS amplitude across three maximal voluntary isometric contractions (%MVIC). Hierarchical multiple regressions, with strength measures in the first block, followed by hip muscle activations in the second block, determined whether hip muscle activation influenced the relationship between hip strength and landing biomechanics. **Results:** When accounting for CON HEXT strength (0.88 ± 0.18 J•BWHT-1), an additional 16% of the variance was explained where greater POST GMED activation (0.24 ± 0.12 %MVIC) predicted less frontal plane hip motion (6.61 ± 2.88°, R^2_{change} P = 0.050, R^2_{total} = 0.42, P = 0.012). When accounting for ECC HEXT strength (0.98 ± 0.32 J•BWHT-1), an additional 23% of the variance was explained where greater PRE GMAX activation (0.14 ± 0.10 %MVIC) predicted greater knee internal rotation moment (0.09 ± 0.05 Nm•BWHT-1, R^2_{change} P = 0.038, R^2_{total} = 0.27, P = 0.042). When accounting for CON HEXT, an additional 19% of the variance was explained where greater PRE GMAX activation predicted less knee external rotation moment (-0.05 ± 0.04 Nm•BWHT-1, R^2_{change} P = 0.050, R^2_{total} = 0.28, P = 0.039). **Conclusions:** The combination of hip strength and muscle activation influences the ability to control motion and forces at the knee and hip during landing. Injury prevention programs should look to implement strategies focused on increasing concentric and eccentric strength of the hip extensors along with activation of the posterior hip muscles during landing.

Plantar Foot Pressures in Those With and Without a Lateral Hip Shift During an Overhead Squat

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Context: Asymmetrical loading between lower limbs can theoretically be explained as an inequality of strength, neuromuscular control, or subconscious reliance on one leg more than the other. Asymmetries are often identified utilizing costly equipment such as force plates and 3D motion analysis cameras. It is important to establish less costly ways of identifying movement and loading asymmetries for clinicians to utilize. One qualitative assessment that may identify asymmetries is recording plantar pressures in those with a 'lateral hip shift' during an overhead squat. **Objective:** To identify differences in plantar foot pressures and center of force in individuals with and without a lateral hip shift during an overhead squat. **Design:** Cross-Sectional Observation. **Setting:** Lab. **Patients or Other Participants:** Twenty-nine (14 males and 15 females) physically active individuals participated in this study. Seventeen individuals with a lateral hip shift during an overhead squat (LAT: Age = 21.2 ± 2.1 years, Height = 175.1 ± 9.1 cm, Mass = 77.6 ± 14.2 kg) and twelve without (CON: Age = 20.8 ± 2.1 years, Height = 177.4 ± 6.8cm, Mass = 77.8 ± 11.1kg) were identified through screening. **Interventions:** Participants were screened for a lateral hip shift while performing five overhead squats to determine group allocation (LAT, CON). After group allocation, participants performed subsequent trials of the overhead squat on the plantar pressure mat while data was being recorded. **Main Outcome Measures:** Plantar pressure variables were captured via a pressure sensor mat during the overhead squat, including side-to-side weight bearing % (WB%), anterior-posterior (AP) excursion (cm), left-right (LR) excursion (cm), and center of force (COF) distance (cm). **Results:** The LAT group demonstrated greater movement in their COF on the plantar pressure mat for total distance (mean difference = 24.27 cm ± 0.4) p = 0.04. The LAT group demonstrated greater LR excursion (mean difference = 2.96 cm ± 3.2) p = 0.03. **Conclusions:** Participants with a lateral hip shift during an overhead squat had greater movement of their COF generally and, more specifically, in the left and right directions than those that did not have a lateral hip shift. Clinically, we may be able to link a lateral hip shift to unequal loading of limbs that may contribute injury.

Neuromechanical Diffferences During a Single-Leg Forward Landing in Females With High and Low Hip Internal Rotation Range of Motion

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Context: Greater passive hip internal rotation range of motion (ROMIR) has been suggested to increase dynamic hip adduction and internal rotation, which are components of functional valgus collapse. How lower extremity biomechanics differ by degree of ROMIR has not been comprehensively examined. **Objective:** To comprehensively examine kinematic, kinetic, and gluteal muscle strength and activation differences in females with high and low ROMIR during a single-leg forward landing. We hypothesized that females with greater ROMIR would display greater dynamic hip adduction and internal rotation, and knee abduction and internal rotation, have weaker gluteal muscles, and would have greater gluteal activation (%maximal voluntary isometric contraction;MVIC) than females with lower ROMIR. **Design:** Cross-sectional. **Setting:** Single-session laboratory study. **Patients or Other Participants:** Females with no history of knee ligament injury or lower extremity surgery and injury-free over the previous six months (N = 20; 22.7 ± 2.9 yrs, 164.2 ± 6.4 cm, 62.7 ± 11.5 kg). **Interventions:** ROMIR was measured prone with the knee flexed to 90°. The transverse angle formed by the tibial diaphysis and true vertical was measured once the hip was internally rotated until initial sacral movement [Intra-rater reliability:ICC2,3(SEM);.97(1.6°)]. MVIC measures were obtained with a handheld dynamometer. For gluteus medius, participants maximally abducted the hip while side-lying with hip in slight extension and knee extended [ICC2,3(SEM);.77(1.6N*m)]. For gluteus maximus, participants maximally externally rotated the hip while seated with hip and knee flexed

to 90° [ICC2,3 (SEM);.92 (0.5N*m)]. 3D motion capture measured hip and knee joint biomechanics during a single-leg forward landing over a barrier (15% height; 40% distance from forceplate) and onto a forceplate. Five trials were obtained and averaged for analysis. Electromyography (EMG) measured peak muscle activation amplitude (%MVIC) during the MVICs and during the landing task. **Main Outcome Measures:** Separate MANOVAs compared high and low ROMIR groups on MVICs, peak activation amplitude (% max), peak and initial kinematics (°), and peak internal moments (Nm*Ht-1*Wt-1) during the landing task. **Results:** The high ROMIR group had slightly weaker gluteus medius MVICs (19.3 ± 2.9 v. 20.9 ± 3.7 N*m; partial η2 = .06; p = .29), and significantly higher gluteus medius activation (0.5 ± 0.2 v. 0.2 ± 0.1 %MVIC; partial η2 = .49; p = .001). Additionally the high ROMIR trended toward greater gluteus maximus activation (1.8 ± 1.6 v. 8 ± 0.7 %MVIC; partial η2 = .17; p = .07), and displayed greater peak hip abduction (-4.3 ± 7.9° v. 3.5 ± 8.2°; partial η2 = .21; p = .04) and knee external rotation (-23.1 ± 13.3° v. -13.9 ± 9.2°; partial η2 = .15; p = .09) than the low ROMIR during the landing phase. **Conclusions:** Females with high ROMIR may have weaker gluteus medii and display increased neural drive resulting in greater hip abduction and knee external rotation during a single-leg landing task. Future work should include a larger sample size to explore compensatory strategies associated with weakened or inefficient gluteal muscles, such as ipsilateral trunk lean.

Electromyography and Ultrasound Imaging Measures of Gluteal Muscle Activity During Nine Exercises

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Context: The electrical activity of gluteus maximus (GMax) and gluteus medius (GMed) has been observed during hip exercises using electromyography (EMG), but few studies have visualized these muscles using ultrasound imaging (USI) concurrently to obtain a comprehensive understanding about muscle activity. While hip exercises are frequently utilized in pathologic populations, activity must first be observed in healthy people for this concomitant measure of muscle activity. **Objective:** To determine activity of GMax and GMed using USI and EMG simultaneously during nine hip exercises. **Design:** Descriptive laboratory study. **Setting:** Laboratory. **Patients or Other Participants:** 20 healthy individuals (Age: 21.9 ± 3.5 years; Height: 173.6 ± 13.5 cm; Mass: 71.7 ± 13.9 kg; 10 Male, 10 Female) participated in this study. **Interventions:** USI and surface EMG of GMax and GMed were assessed simultaneously during exercises performed bilaterally. Exercises included: side-lying hip abduction, active leg-lengthening, clamshells at 30° knee flexion, clamshells at 60° knee flexion, weight shifts, hip hitches, wall squats, single leg squats, and lateral band walks. **Main Outcome Measures:** USI measures for each exercise were normalized by dividing muscle thickness during exercise by quiet table or stance thickness to generate a functional USI percent activation beyond quiet. Mean peak EMG amplitude of GMax and GMed was also normalized to quiet table and stance values. A 1x9 MANOVA compared activation measures for each muscle and Cohen's d effect sizes were calculated with 95% confidence intervals (CI). Pearson's r correlation coefficients were used to determine relationships between measurement techniques. **Results:** GMax USI activity was greater in active leg-lengthening than clamshells at 30° (16.0 ± 4.1%, P = .003, d = 3.9 [CI: 2.83, 4.93]). Weight shifts were also greater than hip hitches in GMax USI (10.4 ± 2.9%, P = .001, d = 3.5 [CI:2.5, 4.5]). GMax EMG showed an increase in clamshells at 60° as compared to weight shifts (7.1 ± 2.1%, P = .02, d = 3.4 [CI:2.5, 4.4]), as well as an increase in wall squats compared to single leg squats (16.7 ± 2.5%, P =< .001, d = -6.7 [CI:-8.3,-5.1]). For GMed, USI was less in side-lying abduction than active leg-lengthening (4.5 ± 4.3%, P = .02, d = -1.0 [CI:-1.7,-0.4]), and greater in clamshells at 30° compared to 60° (5.3 ± 3.9%, P = .003, d = 1.3 [CI:0.7,2.0]). GMed EMG resulted in greater activity in active leg-lengthening than clamshells at 30° (6.5 ± 1.8%, P =< .001, d = 3.6 [CI:2.6,4.6]), less in wall squats than single leg squats (11.3 ± 1.6%, P =< .001, d = -6.9 [CI:-8.5,-5.2]), and less in single leg squats compared to lateral band walks (4.4 ± 2.4%, P =< .001, d = -1.8 [CI:-2.5,-1.0]). No strong significant correlations were found between the measurement techniques for any exercise for either muscle (all r's < 0.4). **Conclusions:** Healthy participants activated their GMax and GMed at different levels during these exercises as measured by both USI and EMG methods of measure with very large effect sizes in many cases. Both tools show clinical usefulness in quantifying gluteal muscle activity, while the lack of correlation between USI and EMG measures demonstrates they are each providing the clinician with unique information.

Muscle Activation Patterns of Lumbo-Pelvic-Hip Complex During Walking Gait Before and After Fatiguing Exercise

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Context: The lumbo-pelvic-hip (LPH) complex consists of musculoskeletal structures responsible for stabilizing the spine and pelvis and facilitating limb movement. Fatigue may affect muscle activation and trunk and lower extremity motion, thus compromising LPH stability. **Objective:** To compare muscle activation patterns of LPH musculature and trunk, hip, and knee kinematics during walking before and after fatiguing exercise. **Design:** Descriptive laboratory study. **Setting:** Laboratory. **Patients or Other Participants:** Twenty-five healthy individuals (16 females, 9 males, age = 20.0 ± 1.7 years, height = 171.0 ± 10.0 cm, mass = 69.0 ± 13.1 kg) participated. **Interventions:** Outcomes were measured before and after 30 minutes of exercise. The exercise protocol consisted of five series each consisting of five minutes of treadmill walking at 1.3 m/s and one minute of jump squats and lateral hops. The treadmill incline increased by 0.5° per minute and until a 8.5° incline was reached. **Main Outcome Measures:** EMG amplitudes from rectus abdominis, external oblique, erector spinae, gluteus medius, vastus lateralis, and vastus medialis were measured during walking and normalized to quiet standing values. Simultaneously, 3D trunk, hip, and knee kinematics were measured with a 12 camera motion capture system integrated with an instrumented treadmill. Data were reduced to 101 points to represent 0-100% of the gait cycle. For each measure, means and 95% confidence intervals were calculated over the entire gait cycle before and after exercise. Periods where confidence intervals did not overlap for three or more consecutive points were considered significantly different and mean differences (MD) were then calculated. Rate of perceived exertion (RPE), as measured on the Borg scale, and heart rate were also compared before and after exercise. **Results:** Heart rate and RPE increased after exercise (pre-exercise heart rate = 78.6 ± 9.0 bpm, post-exercise = 178.1 ± 14.4 bpm; RPE after 5 minutes of exercise = 8.2 ± 1.4, post-exercise RPE = 15.8 ± 2.1). After exercise, rectus abdominis amplitude significantly increased during loading (0-6%, MD = 0.67 ± 0.11), midstance (29-34%, MD = 0.75 ± 0.04), terminal stance (44-54%, MD = 0.58 ± 0.04), and late swing (93-100%, MD = 0.75 ± 0.07), while erector spinae activation increased during initial swing (65-68%, MD = 0.92 ± 0.11). There were also significant increases after exercise during swing for vastus lateralis (68-85%, MD = 1.12 ± 0.30) and vastus medialis (73-86%, MD = 1.80 ± 0.19). There were no significant differences in external oblique or gluteus medius amplitudes. There were no significant differences in trunk or hip or trunk sagittal and frontal plane kinematics, however there was increased knee flexion after exercise during swing (84-93%, MD = 5.63 ± 11.24°). After exercise, the trunk was less rotated toward the contralateral side from initial contact to midstance (0-27%, MD = 1.09 ± 1.79°) and the hip was less internally rotated during loading (8-15%, MD = 3.20 ± 0.39°) and midstance (22-32%, MD = 3.01 ± 0.21°). **Conclusions:** Fatigue significantly influenced the activation patterns of superficial musculature and kinematics of the LPH complex during walking. Increased muscle activation with decreased rotary movement may be an effort to maintain LPH stability in a fatigued state by increasing trunk stiffness.

Treating Patients Reflexively: The Effects of a Novel Approach on Patients Classified With a Grade 1 Hamstring Strain

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Background: Hamstring strains have an injury rate of 3.05 per 1000 athlete exposures in college athletics. Most hamstring strains occur during practice and are a result of a noncontact mechanism. This a priori case series study aimed to record the effect of a novel treatment on grade 1 hamstring strains. Three patients (2 males and 1 female averaging 19.3 ± 1.5 years old) actively participating in college athletics were treated for a unilateral grade 1 hamstring strain, after meeting the inclusion criteria of having acute sudden pain in their posterior thigh during practice or competition, Numeric Pain Rating Scale (NRS) score of ≥2/10, Active Knee Extension Test (AKET) measurement of ≤70° on involved side, and a Patient Specific Functional Scale (PSFS) score of ≤8/10. The standard of care for acute hamstring strains emphasizes tissue protection, lengthening, strengthening and corrective movement exercises to relearn motor patterns focused on trunk stability and agility. While this is the excepted standard of care, an important component may be neglected. At the onset of injury, the patient's central nervous system (CNS) reflexively (i.e., unconsciously) responds by protecting the injured segment. This reflexive protection mechanism is important to limit further injury, but the response may be become stuck in a state of over-readiness or protection. This may create unnecessary active pain patterns, impeding return of normal range of motion and strength, and delaying return to activity. Modulating the involved neural connections reflexively can reset the CNS to a more normal stasis and facilitate quicker patient return to activity. The innovative treatment paradigm, Primal Reflex Release Technique (PRRT), created by John Iams, is indicated to modulate this heightened reflexive protection

mechanism to restore natural neuromuscular function. **Treatment:** Patients were evaluated within 24 hours of onset of pain and treatment was initiated after inclusion and consent was established. All patients were treated with PRRT, one treatment on three consecutive days. Each patient was treated with four distinct treatment areas (hamstrings, anterior lower leg, medial knee and sacral iliac joint) with total treatment time lasting 3-5 minutes. The described PRRT treatment was the only treatment provided. All outcome measures were completed at pre-initial treatment, post-initial treatment and at one week follow-up. Pain was scored on the NRS, disablement was reported on the Disablement in the Physically Active Scale (DPAS), a modified PSFS was implemented to measure perceived function during multi-segment forward flexion and hamstring ROM was measured using the AKET. Descriptive data analysis was completed using Excel. **Results:** Each outcome measure, NRS, DPAS, PSFS scores and AKET measurements, improved from initial treatment to 1-week follow-up. MCID were recorded for NRS (Pre: 5.7 ± 2.1 to Post: 3.7 ± 2.1 to 1-week: 0.3 ± 0.6), DPAS (Pre: 41.3 ± 8.1 to 1-week: 8 ± 9.1), PSFS (Pre: 4.7 ± 2.5° to 1-week: 9 ± 1°) and an MDC AKET (Pre: 43.3 ± 17.7° to 1-week: 70.6 ± 6.4°). All patients returned to limited participation 2 days following injury and were discharged for unrestricted activity at 7.3 ± 5.9 days. All three patients reported no re-injury, with minimal disablement (DPAS: 1.3 ± 2.3) and had no pain (NRS: 0 ± 0) at a 6-week follow-up. **Uniqueness:** The novel treatment of modulating the CNS in patients that were classified with grade 1 hamstring strains had an effect on the resolution of pain and deficits in ROM within a week of onset. All assessments and treatments were conducted by an ATC and novice level PRRT practitioner. **Conclusions:** In the three patients classified with grade 1 hamstring strains, PRRT was utilized as the only therapeutic intervention. Through modulation of the CNS, the outcomes reported by the patients were both meaningfully and clinically significant. Based on the results exceeding the standard of care, integration into clinical practice and further research is warranted.

Lower Extremity Muscle Activation Patterns During Running Tasks Between Individuals With and Without a Previous Hamstrings Injury

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Context: Speculations of neuromuscular inhibition following a hamstrings strain exists, however, muscle activation patterns of the hip and knee musculature during running tasks following a previous hamstrings strain have been relatively unexplored. **Objective:** To compare lower extremity muscle activation patterns during a straight ahead run, unanticipated cut and deceleration maneuver between individuals with and without a previous hamstrings strain. **Design:** Case-control **Setting:** Laboratory **Patients or Other Participants:** Ten recreationally active individuals with a history of hamstrings strain within 5 years (6 males, 4 females; age = 21.8 ± 1.23 years; height = 1.77 ± 0.07 m; mass = 78.32 ± 11.44 kg; Hamstring Outcome Score = 89.37 ± 7.2%), were matched to 10 individuals with no history of hamstrings strain (6 males, 4 females; age = 22.30 ± 1.70 years; height = 1.78 ± 0.082 m; mass = 78.35 ± 12.79 kg; Hamstring Outcome Score = 96.75 ± 2.83%). All participants were physical activity ≥30 minutes, 3 times per week and had no lower extremity injury within 4 months. Participants were excluded if they reported lower extremity surgery or history of neurological complications. The involved limb was defined as the limb with a previous hamstrings strain and the matched limb of the healthy participant. **Interventions:** Wireless EMG surface electrodes were placed bilaterally on the Gluteus Maximus, Gluteus Medius, Rectus Femoris(RF), Vastus Medialis, Biceps Femoris, Medial Hamstrings, and Lateral Gastrocnemius. Maximum Voluntary Isometric Contraction was performed to isolate each muscle. All participants ran straight ahead at an approach speed between 4.5 and 5.0m/s to start each trial. Upon crossing the timing gaits, placed two meters from the force platform, a cue triggered the participant to either continue running straight ahead, cut on the involved side or decelerate. All tasks were randomized and unanticipated for each trial. Collection was complete after 5 successful trials of each task. Trials were successful if proper speed was maintained and the entire foot landed in the force plate. The gait cycle included the preparatory swing phase (0.2s prior to initial contact) and the absorption and propulsion phases, as determined by the anterior-posterior ground reaction force curve of each trial. **Main Outcome Measures:** The dependent variables included maximum normalized EMG(%EMGmax) and time of maximum (%Cycle out of 100%), for each muscle. Between-group comparisons in %EMGmax and %Cycle for each muscle were examined with independent t-tests and effect sizes (ES). The alpha level was set at $p \leq 0.05$. **Results:** The HG had lower RF %EMGmax during the straight run (Hamstring: 37.19 ± 17.64%, Control: 65.27 ± 37.09%; $p = 0.05$, ES = 1.0). No other statistically significant differences were identified ($p > 0.05$). **Conclusions:** The significant reduction of RF %EMGmax during the straight run in participants with a previous strain as compared to the control group may suggest a possible protective neuromuscular adaptation. This adaptation may reduce the demands required by the hamstrings to counter the agonist forces of the RF following a hamstrings strain. Further investigation is warranted to confirm this finding.

The Immediate Effects of Graston Technique© on Hamstring Flexibility Compared to a Control

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Context: Poor hamstring flexibility increases the risk of sustaining a muscle strain during physical activity. By identifying interventions that are effective at improving hamstring flexibility, clinicians can look to reduce injury rates among physically active patient populations. **Objective:** To determine if a single modified treatment of Graston Technique© protocol is effective in increasing hamstring flexibility immediately after treatment. **Design:** Randomized controlled trial **Setting:** Human Performance Laboratory **Patients or Other Participants:** Thirty-two subjects who met the inclusion criteria were randomly assigned to one of two intervention groups: 1) Graston Technique© (n = 16; Age = 20.7 ± 2.5 yr, Height = 176.0 ± 2.8 cm, Weight = 73.5 ± 3.5 kg), or 2) control (n = 16 Age = 21.2 ± 3.9 yr, Height = 176.7 ± 2.8 cm, Weight = 81.8 ± 3.8 kg). Subjects were included if they had decreased hamstring ROM measured with a passive knee extension (PKE) test of less than 60 degrees, had no lower extremity injury within the past year, and had not participated in an intensive leg workout 48 hours prior to testing. **Interventions:** All subjects participated in one, single-blind data collection session. Only the subject's dominant leg was included in the study. PKE measurements were used to capture hamstring range of motion using a digital inclinometer (Lafayette Inst. Co., Lafayette, IN) at two separate times: 1) after a 5-minute warm-up (Pre), and 2) immediately post intervention (Post). A visual analog scale was also used Pre and Post intervention to determine subject's perceived flexibility. The GT intervention consisted of 4 different techniques. Scanning strokes were done first and then smaller instruments were used to address soft tissue adhesions. Two techniques were performed while subjects were prone, and two while subjects were supine. Control subjects sat in a resting position with their hips and knees at 90 degrees and their feet flat on the floor. Interventions for both groups lasted 12 minutes. Two repeated measures analysis of variance (ANOVA) were completed, one for each dependent variable (hamstring flexibility and perceived hamstring flexibility). **Main Outcome Measures:** Hamstring flexibility (degrees) and visual analog scale (centimeters). **Results:** A significant time by group interaction was identified for range of motion ($F_{1,30} = 85.1$, $p < .01$), and perceived flexibility ($F_{1,30} = 21.04$, $p < .01$). The mean difference in PKE was 9.5° for the GT group (GT: Pre = 52.5 ± 1.8°, GT: Post = 62.0 ± 2.1°), while the control group had no significant change (Control-Pre = 52.3 ± 1.8°, Control-Post = 50.5 ± 2.1°). Additionally, the GT group perceived a greater increase in hamstring flexibility (mean difference VAS = 2.1 cm) compared to the control group (mean difference VAS = .5 cm). **Conclusions:** Our results indicate that GT is an effective intervention for increasing hamstring flexibility when measured immediately after treatment application. Additionally, subjects report subjective improvements in flexibility following GT application. These results may prove beneficial for reducing sport related muscle injuries.

Compressive Versus Decompressive Soft Tissue Therapy on Acute Hamstring Flexibility and Pain in Male Athletes With Perceived Hamstring Tightness

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Context: The Graston Technique® (GT) and Myofascial Decompression (MFD) are commonly used in treating hamstring injury, but limited research exists to determine immediate effectiveness and beneficial outcomes of these treatments. **Objective:** Compare the acute effects of GT and MFD on hamstring flexibility, strength, and patient-reported outcome measures of perceived function and pain. **Design:** Pretest-posttest randomized group study. **Setting:** Controlled laboratory setting. **Patients or Other Participants:** Twenty Division I collegiate male athletes (21.35 + 1.76 years, 82.85 + 8.36 kg, 175.89 + 5.93 cm) with complaints of perceived hamstring tightness and pain voluntarily participated. Participants were randomly assigned to one of two interventions (GT or MFD) of ten participants each. **Interventions:** The GT group received sweeping strokes of 30 per minute distal to proximal, and 30 strokes per minute proximal to distal repeated for 4 minutes using the GT-1 instrument. MFD participants received three minutes of static treatment using six plastic-valve cups along the length of the hamstrings, followed by 1 minute of single cup gliding. **Main Outcome Measures:** Dependent variables were assessed before and after intervention. Flexibility (ROM) was assessed via digital protractor in supine straight-leg-raise position. Peak force (PF), average force (AvgF), torque (TQ), and overall strength (STR)

was assessed by hand-held dynamometer in prone isometric knee flexion at 90°. Patient-reported outcomes of perceived function and pain and overall treatment effectiveness were assessed with the Perceived Functional Ability Questionnaire (PFAQ) and the Global Rating of Change Scale (GROC). Paired sample t-tests and a two-way ANOVA were used to compare mean differences in pre and post-test measurements of flexibility and strength and perceived function, and differences between interventions. **Results:** Aggregate data showed significant improvements regardless of treatment in ROM ($t = -5.41$, $p < 0.001$), PF ($t = -3.26$, $p = 0.004$), AvgF ($t = -3.47$, $p = 0.003$), TQ ($t = -3.24$, $p = 0.004$) and STR ($t = -3.34$, $p = 0.003$), and perceptions of flexibility ($t = -3.90$, $p = 0.001$), pain ($t = 2.76$, $p = 0.01$) and sport performance ($t = 3.18$, $p = 0.005$) as identified via the PFAQ. No differences in dependent variable comparisons were observed between groups. Perceived pain and flexibility improved following either treatment, however there was no significance found between groups. The GT group felt "quite a bit better" (5.4 + 1.17) compared to MFD reporting "moderately better" (4.3 + 1.42) on GROC scores after treatment, but no clinical meaningful change exists between groups. **Conclusions:** Both GT and MFD methods were effective in increasing hamstring flexibility and strength and improvements in perceptions of flexibility, pain and performance immediately following treatments. Subjects in both groups responded positively to treatment according to GROC measures. Considering there were no significant differences between interventions, it can be recommended that GT and MFD are useful treatment strategies for patients experiencing hamstring tightness or pain.

Instrument Assisted Soft Tissue Mobilization (IASTM) Graston Technique® Treatment of Dance Injuries

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Context: With a high injury rate among dancers, 65% of which are reported to be overuse syndromes, healthcare practitioners need to be equipped with the most current, evidence based technologies which will help performing artists return to functional activity using the least amount of time. **Objective:** Determine if Instrument Assisted Soft Tissue Mobilization (IASTM) Graston Technique® (GT) is a more effective treatment for chronic dance injuries than manual Soft Tissue Massage (STM) alone. **Data Sources:** A PubMed literature search without language restrictions was performed on the use of IASTM GT and STM treatments for dance related injuries between the years 1995-2016. The search strategy was IASTM GT and dance injury. **Study Selection:** Risk of bias was assessed with the Cochrane criteria. Studies which addressed conditions in which GT is indicated and correlates with common dance injuries were included: Achilles Tendinitis/osis; Cervicothoracic Sprain/Strain; Lumbosacral Sprain/Strain; Myofascial Pain Syndromes; Patellofemoral Disorders; Plantar Fasciitis/osis; Patients Demonstrating Central and/or Peripheral Sensitization; Post Surgeries such as Joint Replacements/RTC Repairs; Rotator Cuff Tendinitis/osis; Scar Tissue/Post-Surgical Scars; Shin Splints; and Women's Health. **Data Extraction:** One principle investigator analyzed the data found within this systematic review. Five clinical trials, two case series, three case studies, one pilot study, and two animal studies were included. All clinical and case studies contained improved outcome measures in subjective and objective clinical controls with use of GT on tendinopathies. One clinical trial showed a decrease in practitioner discomfort and fatigue with use of IASTM. One animal study showed altered microvascular morphology and the other accelerated knee ligament healing with use of GT. Hierarchy of evidence was taken into consideration when selecting studies for review. **Data Synthesis:** While all the studies showed favorable outcome measures with the use of GT on tendinopathies and a decrease in practitioner discomfort and fatigue with use of IASTM, the quality of evidence of the studies in this systematic review are low in hierarchy of evidence. There is insufficient research on the use of GT on dance specific injuries and returning those with dance specific injuries to functional activity in the least amount of time. Further research on the use of GT within the dancer patient population will help validate the use of GT for dance specific related injuries. **Conclusions:** The available research suggests that with the combination of a comprehensive fitness program, incorporating the use of GT in treating chronic overuse dance injuries is likely to aid dancers in returning back to functional activity faster, as well as provide long term results associated with the proper realignment of tissues. The evidence suggests clinicians benefit as well due to the decreased amount of strain placed on the joints of their hands. As such there is likely the potential of increasing the longevity and capacity of clinicians for manually treating their dancer patients by using GT.

Massage and Instrument Assisted Soft Tissue Mobilization Acutely Increase Hamstring Flexibility

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Context: Massage and instrument assisted soft tissue mobilization (IASTM) are commonly used to increase hamstring flexibility following a previous injury. Massage and various forms of IASTM have only anecdotal evidence supporting the effects of increasing hamstring flexibility. **Objective:** The purpose of this study is to determine the effectiveness of massage and IASTM on hamstring range of motion and self-perceived change. **Design:** Crossover. **Setting:** Laboratory. **Patients or Other Participants:** Thirty participants with less than 80° of hamstring flexibility volunteered (age = 23.9 ± 3.3 y; height = 175.4 ± 7.9 cm; mass = 79.2 ± 12.7kg). We excluded anyone with previous history of femur/hip fractures, or any allergy to lotions/emollient. **Interventions:** The independent variable was intervention (applied in random order), massage or IASTM. We randomly assigned treatment limb and measured hamstring flexibility to determine inclusion using belted stabilization at the anterior superior iliac spine and opposite leg. The patient was prone and the hamstring was relaxed for most of the treatment. When treatment was applied on a stretch the participant was supine. The massage protocol included a 5-min tissue warm-up applying effleurage, 5-min petrissage on the relaxed hamstring, 5-min petrissage on the hamstring on a light stretch, and 2-min effleurage to conclude. The completed massage protocol was 17 minutes of treatment. The IASTM protocol included 5-min on a stationary bicycle, 2-min of scanning strokes (GT 5), 4-min fanning strokes (GT 4) while the hamstring was relaxed and 4-min while the hamstring was on a light stretch. If needed, J-strokes were applied (GT 3), as one might do using clinical decision making to treat restrictions within the hamstring. We applied a 30-sec hamstring stretch after each treatment protocol. Participants were asked to complete the Global Rating of Change scale (GROC) following each treatment session. **Main Outcome Measures:** The dependent variable was hamstring flexibility measured using a digital inclinometer through a passive straight leg raise. We collected measurements of hamstring flexibility pre- and post-treatment and calculated a change score. We used separate dependent t-tests to determine the effect of the intervention on both dependent variables. Significance was set at $p < 0.05$ a-priori. **Results:** There were no statistical significances identified between the interventions for hamstring flexibility ($t_{29} = 0.183$, $p = 0.856$, $1\text{-}\beta = 0.86$) or GROC ($t_{29} = 0.226$, $p = 0.823$, $1\text{-}\beta = 0.83$). Both interventions increased hamstring flexibility (mean differences = 11.0 ± 1.1°). **Conclusions:** Our findings suggest there is little difference between massage and IASTM, using clinically applicable protocols, in improving acute increases in hamstring flexibility. However, both interventions yielded a substantial change of greater than 10 degrees of motion. Both interventions increase hamstring flexibility immediately following treatment and could be used in clinical practice for immediate ROM gains at the hamstring.

A Comparison of Instrument-Assisted Soft Tissue Mobilization and Dry Cupping and Their Effect on Shoulder Range of Motion

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Context: Repetitive overhead motion leads to soft tissue and osseous adaptations at the glenohumeral (GH) joint. Research suggests that external rotation (ER) increases while internal rotation (IR) decreases in the dominant shoulder of this population. When IR decreases beyond the gain in ER, the condition is called GH internal-rotation deficit (GIRD) and has been associated with GH injury. Addressing GIRD has become common practice and numerous methods for improving GH motion have been suggested. However, the efficacy of these methods is not fully understood at this time. **Objective:** To compare the effects of instrument-assisted soft tissue mobilization (IAST) and dry cupping (DC) on GH motion. **Design:** A randomized pretest post-test with control group design. **Setting:** Athletic training facility. **Patients or Other Participants:** Thirteen NCAA D-I volleyball, water polo, baseball and softball athletes (age = 20.15 ± 1.46 years, height = 172.34 ± 13.11 cm, mass = 74.56 ± 10.85 kg) who were not suffering from any injury or condition that would affect GH motion or from any contraindication to IAST or DC. **Interventions:** Subjects were randomly assigned to one of three treatment groups, IASTM, DC or control (CON). Subjects in the IASTM group received 10-min of IASTM using Graston® instruments to the dominant supraspinatus, infraspinatus, teres minor, latissimus dorsi and musculature around the scapular border. Subjects in the DC group received 10-min of DC using the AcuZone® cupping set over the same area. The subjects received three treatments each week for a period of three weeks. The CON group received no treatment. **Main Outcome Measures:** GH ER, IR and horizontal adduction (HAd) were assessed

immediately before and after the initial treatment session and on the day following the ninth and final treatment using an Acumar™ digital inclinometer. Three measurements were taken in each direction and the mean of the three was recorded. **Results:** Neither treatment provided an acute change in motion as a two-factor mixed analysis of variance failed to reveal significant Treatment x Test interactions for IR ($F_{2,10}$ = .044, p = .957), ER ($F_{2,10}$ = .176, p = .841) or HAd ($F_{2,10}$ = .174, p = .843). When comparing chronic treatment, a significant Test main effect ($F_{1,10}$ = 14.67, p = .003) was observed for ER. ER was significantly greater after three weeks of treatment (133.72 ± 11.78°) as compared to the pretest (116.92 ± 15.99°). Treatment had no effect however, as three week changes in IR ($F_{2,10}$ = .144, p = .868), ER ($F_{2,10}$ = 1.73, p = .226) or HAd ($F_{2,10}$ = .281, p = .761) were not observed in either group. **Conclusions:** There was a significant increase in ER after the three week protocol however there was no significant increase in either internal rotation or horizontal adduction. This can be attributed to the subjects' continued participation in their sport naturally increasing ER throughout the season. Neither IASTM nor DC improved GH motion regardless of direction. It is possible that these treatments might require longer durations or a longer adaptation period.

Treatment Outcomes of Myofascial Decompression (Cupping Therapy) on Hamstring Pathology

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Context: Myofascial decompression (MFD) or "cupping therapy", and self-myofascial release (SMR) using a foam roller are contemporary methods of soft tissue therapy. Low-level evidence exists to support foam rolling to increase flexibility in the lower extremity, but research is scant regarding outcomes of MFD on flexibility and function in patients with hamstring pathology. **Objective:** Investigate flexibility and patient-rated outcomes of two soft tissue therapies; myofascial decompression (MFD), and self-myofascial release using a foam roller (SMR) on patients with diagnosed hamstring pathology. **Design:** Pretest-posttest randomized group experimental study. **Setting:** Controlled laboratory setting. **Patients or Other Participants:** Seventeen collegiate athletes [13 males (20.6 +/- years, 184.9 +/ -cm, 90.8 +/- kg) and 4 females (20.5 +/- years, 167.1 +/ -cm, 62.7 +/- kg)] with symptoms including tightness, pain, decreased strength, and decreased flexibility voluntarily participated. Participants were randomly assigned to one of two interventions (9 assigned to the MFD group and 8 to the SMR group). **Interventions:** The MFD group received three minutes of static treatment using six plastic-valve suction cups along the length of the hamstrings, followed by 10 repetitions of active knee flexion, and 10 repetitions of passive straight leg raise with the cups in place. Participants in the SMR group received 10 minutes of moist heat treatment over the hamstrings followed by 60 seconds of general mobilization over the entire hamstring area, and 90 seconds of targeted foam rolling on the area of most perceived tightness. **Main Outcome Measures:** Dependent variables were assessed before and after intervention. Flexibility (ROM) was assessed via digital protractor in supine straight-leg-raise position. Patient-reported outcomes of perceived function and pain were assessed with the Perceived Functional Ability Questionnaire (PFAQ) and overall treatment effectiveness assessed by the Global Rating of Change Scale (GROC). Paired sample t-tests were used to compare mean differences in pretest and posttest measures of flexibility, treatment effectiveness, and each of the PFAQ measures of perception. One-way ANOVA was used to compare differences between the two treatment groups. **Results:** Aggregate data showed significant improvements in ROM regardless of treatment (t = -3.10, p = 0.01). Subjects in the MFD group noted a greater perception of hamstring flexibility according to the PFAQ compared to SMR (F1,15 = 5.43, p = .034). Subjects receiving MFD indicated a statistically significant higher score on the GROC compared to SMR (F1,15 = 11.68, p = 0.00). Subjects in the MFD group indicated "moderately better" response to treatment compared to those in the SMR group indicating "tiny bit better" to a "little bit better." **Conclusions:** Both MFD and SMR are beneficial in increasing hamstring length in those with complaints of hamstring pathology symptoms. Participants receiving MFD felt an enhanced treatment effect over SMR for perceived benefits of hamstring flexibility. Additionally, participants receiving MFD indicated a better overall response of treatment compared to SMR.

The Difference Between Y Balance Test Scores in a Cohort of Collegiate Athletes With or Without Chronic Ankle Instability

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Context: Individuals with a history of previous ankle sprains have shown residual symptoms and perceived instability upon returning to activity, which may lead to the development of chronic ankle instability (CAI). These individuals have experienced deficits in postural control during a quiet standing/static balance activity. During sport activity, one is rarely in a static balance position; therefore, it is important to assess balance dynamically. The Y Balance Test (YBT) incorporates single-limb balance stance while including dynamic balance tasks involving reaching with the opposite limb. **Objective:** To determine the difference in YBT scores in those with or without CAI. **Design:** Retrospective cohort. **Setting:** University athletic training research laboratory. **Patients or Other Participants:** Seventy-one (37 male, 34 female) university student-athletes (age = 18.4 ± 0.6 yrs., height = 173.7 ± 9.1 cm, mass = 73.0 ± 15.4 kg), with (n = 35) or without CAI (n = 36) participated. CAI was determined using Cumberland Ankle Instability Tool (CAIT) scores (CAI £ 25, control (CONT) ≥ 26) and a history of at least one ankle sprain. **Interventions:** Injury questionnaire and CAIT were administered to determine number of previous ankle sprains and the presence of CAI. Single limb reach distance was tested using the YBT in three reach directions; anterior (ANT), posteromedial (PM), and posterolateral (PL). Differences between limbs in the ANT (ANTdiff), PM (PMdiff), and PL (PLdiff) directions, along with differences between composite scores (COMP), combining all directions and normalized to limb length, were calculated. YBT reliability has been previously established as good to excellent; intrarater (ICC= .85-.91) and interrater (ICC= .99-1.00) and composite reach score (intra-ICC= .91 and inter-ICC= .99). **Main Outcome Measures:** Our independent variable was ankle stability status (CAI vs. CONT), while the four dependent variables included ANTdiff, PMdiff, PLdiff, and COMP. Separate T-test analyses were performed on each DV to determine differences between means. **Results:** There was a significant difference in ANTdiff between CAI (3.6 ± 2.4 cm) and CONT (1.9 ± 1.5 cm, p = .001, t = 3.57); this also translated into a strong effect size (Cohen's d = 0.85). There were no significant differences in PMdiff (4.6 ± 2.94 cm CAI, 3.6 ± 2.87 cm CONT), PLdiff (4.3 ± 3.23 cm CAI, 4.2 ± 3.18 cm CONT), or COMP (3.0 ± 2.66 cm CAI, 2.6 ± 1.79 cm CONT). **Conclusions:** Subjects with CAI produced a higher ANTdiff score compared to those without CAI. The increased reach distance difference between limbs, illustrates asymmetry in bilateral ankle dorsiflexion ROM in those with CAI and supports existing evidence demonstrating deficits in this vital ankle movement. We support the use of Y Balance testing as a reliable, easy to use tool to assess dorsiflexion ROM, dynamic balance, and flexibility in those with CAI.

The Relationship Between Center of Pressure Measures and Reach Distance While Performing the Star Excursion Balance Test in Individuals With and Without Chronic Ankle Instability

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Context: Center of pressure (COP) measurements via a force platform have been used to assess postural stability deficits in individuals with Chronic Ankle Instability (CAI). However, no studies have examined COP measures while performing a dynamic postural stability test such as the Star Excursion Balance Test (SEBT), which may reveal different COP activity. The anterior reach direction (AN) has consistently shown deficits in CAI populations. **Objective:** To determine if a relationship exists between COP measures and reach distance in the anterior (AN) direction while performing the SEBT. **Design:** Cross-sectional **Setting:** Biomechanics Laboratory **Patients or Other Participants:** Seventy participants were categorized into two groups. The CAI group (23 females, 12 males; age 21.2 ± 2.3 yrs; height 169.3 ± 10.8 cm; mass 70.1 ± 15.0 kg) had at least 1 moderate-severe ankle sprain, 2 episodes of "giving way" at the ankle, Cumberland Ankle Instability Tool (CAIT) score ≤25, and an Identification of Functional Ankle Instability (IdFAI) score ≥11 indicating poor function. The control group (23 females, 12 males; age 21.6 ± 2.9 yrs; height 169.2 ± 10.4 cm; mass 69.3 ± 14.2 kg) had no history of ankle injury, CAIT scores ≥29, and IdFAI scores ≤10 indicating good function. **Interventions:** Participants performed 3 test trials of the SEBT on a biomechanical force-plate. All test trials were measured by a single rater (ICC2,1 > 0.89). Three directions

(anterior [AN], posterior-medial [PM], and posterior-lateral [PL]) of SEBT were performed, but only AN trials were analyzed as a preliminary study. **Main Outcome Measures:** The reach distance was averaged across 3 test trials and normalized to leg length (%). The COP data were collected and calculated into COP standard deviation (COPSD) in the anterior-posterior (A-P) and the medial-lateral (M-L) directions in cm. Pearson-product moment correlations were used to investigate the relationship between each COPSD measure and reach distance in the AN direction of SEBT in each group. **Results:** In the CAI group, a moderate statistically significant relationship was found between reach distance in the AN direction and the M-L COPSD ($r = -0.40$, $p = 0.02$). However, no significant relationship was found between A-P COPSD (A-P COPSD: $r = 0.21$, $p = 0.24$) and reach distance. In the control group, no statistically significant relationships were found between reach distance achieved in the AN direction of the SEBT and all COP measures (A-P COPSD: $r = 0.17$, $p = 0.32$; M-L COPSD: $r = 0.08$, $p = 0.67$). **Conclusions:** The relationship identified indicates individuals with CAI may need to constrain the M-L COPSD while performing the AN reach direction of the SEBT in order to maximize their performance. Therefore, clinicians may need to focus rehabilitation training for better control of the COP in the CAI group in the M-L direction. This may enhance the ability to adjust COP during dynamic postural control tasks such as the AN reach direction of the SEBT, resulting in better performance.

Reliability & Responsiveness of Time-to-Boundary in Those With a History of Lower Extremity Injury

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Context: Time to boundary (TTB) is a postural control assessment technique used to capture single limb balance alterations related to lower extremity injury and rehabilitation. While it has been shown to be valid in detecting differences from these two factors, it remains unclear how responsive this measurement technique is as it relates to the typically-occurring error across individuals and time. **Objective:** To evaluate the reliability and responsiveness of TTB variables captured during single limb stance in those with chronic ankle instability (CAI) across a two-week time period. **Design:** Reliability Study. **Setting:** Research Laboratories. **Patients or Other Participants:** Seventy-seven patients with self-reported CAI (31 males, 46 females; age: 22.8 ± 4.5 yrs; height: 171.3 ± 9.5 cm; mass: 74.6 ± 16.1 kg) participated. CAI was defined as at least two episodes of "giving way" within the past 3 months; scoring <90% on the Foot and Ankle Ability Measure (FAAM), and scoring <80% on the FAAM-Sport. **Interventions:** All patients performed 3, 10-second trials of eyes open and eyes closed single-limb stance on a force plate standing on the self-reported higher-functioning limb. After baseline testing, patients were instructed to maintain normal daily activities for 2-weeks before being reassessed using the same single-limb balance assessment protocol. **Main Outcome Measures:** TTB was calculated using the COP position and velocity data for the mediolateral (ML) and anteroposterior (AP) directions in relation to the boundaries of the base of support. The TTB minima were then identified. The minima represent the theoretical points within the COP profile where a person is highly likely to lose balance if a change in direction does not occur. From the identification of the minima, the mean of minima was calculated for both the AP and ML directions with eyes open and closed. Reliability estimates were calculated for using ICC(1,3) for each variable. To determine responsiveness, the standard error of the measure (SEM) was calculated from the reliability estimates and the subsequent minimum detectable change (MDC) was estimated (SEM*21/2). **Results:** For eyes open, the mean of TTB minima demonstrated excellent reliability with relatively low MDCs in both directions (ML-TTB ICC(1,3) = 0.93, MDC = 0.33 s; AP-TTB ICC(1,3) = 0.94, MDC = 0.91 s). Similarly, the eyes closed, the reliability estimates were excellent (ML-TTB ICC(1,3) = 0.95, MDC = 0.15 s; AP-TTB ICC(1,3) = 0.95, MDC = 0.42 s). **Conclusions:** The reliability and responsiveness of the mean of TTB minima in both the ML and AP directions were consistently excellent with relatively low MDCs. Based on the results, eyes closed MDCs appear to be about half the amount of eyes open. This is consistent with eyes open TTB values typically being double the magnitude of eyes closed. Our findings suggest that there is good precision of TTB estimates that afford the opportunity to potentially capture meaningful changes in postural control as a result of injury or rehabilitation using these outcomes.

Novel Postural Stability Assessments in Individuals With Chronic Ankle Instability Using Engineering Control Theory

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Context: Substantial evidence has linked chronic ankle instability (CAI) to altered postural stability, leading to deteriorations in physical activity and health-related quality of life. Therefore, it is imperative to appropriately assess inefficient postural control strategies to develop intervention strategies to deter long-term complications. Novel engineering control theory techniques, such as Nyquist and Bode stability analyses, evaluate center of pressure (COP) waveform patterns to assess postural stability of the underlying dynamics of a system. These techniques not only classify the individuals' stability, but also provide a quantifiable measure of how stable or unstable the individual is, the source of the individuals' instability and what changes should be made to make the individual more stable. However, a study designed specifically to examine postural stability with the Nyquist and Bode stability criteria in individuals with CAI is lacking. **Objective:** Examine postural stability using Nyquist and Bode methodologies in individuals with and without CAI and determine if there were differences in traditional postural control measures between those with and without postural instability identified by Nyquist and Bode analyses. **Design:** Case-control study. **Setting:** Research Laboratory. **Patients or Other Participants:** Twenty-nine participants with self-reported CAI (13M, 16F; 22.07 ± 3.43 yrs; 169.77 ± 8.71 cm; 72.42 ± 15.08 kg) and 15 healthy controls (4M, 11F; 21.07 ± 3.88 yrs; 165.82 ± 6.76 cm; 65.95 ± 13.67 kg) volunteered. **Interventions:** Participants performed single-leg eyes closed static balance trials. Using a force platform, COP trajectories in the anteroposterior (AP) and mediolateral (ML) directions were recorded during three, 20-second trials. **Main Outcome Measures:** The Nyquist and Bode stability criteria were implemented to classify COP waveforms as stable or unstable based on the resulting gain and phase margins. Time-to-boundary (TTB) mean of minima (seconds) and COP velocity (COPV) were calculated as traditional postural control measures. A Chi-Square test was used to analyze postural stability differences between the CAI and control groups. Independent t-tests were utilized to compare traditional postural control measures between CAI participants with postural stability and instability classified based on Nyquist and Bode analyses. Significance was set a priori at $P<0.05$. **Results:** Chi-Square analysis demonstrated that the Nyquist and Bode stability criteria were associated significantly with the group status ($x^2 = 8.12$, $P = 0.003$, Odd ratios = 7.60). Nineteen of 29 participants with CAI were classified as having "postural instability", while only three out of 15 healthy controls had unstable COP waveform patterns. No differences existed in any of traditional postural control measures between CAI participants with postural instability and stability ($P > 0.05$). **Conclusions:** The Nyquist and Bode stability criteria identified different COP waveform patterns in participants with CAI. However, traditional postural control measures produced no differences in postural control strategies within CAI participants. The Nyquist and Bode stability criteria may be an alternative method that has capability to evaluate postural stability in a CAI population.

Using Control Theory Techniques to Assess Dynamic Ankle Stability in Individuals With Chronic Ankle Instability

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Context: A growing body of evidence suggests that altered dynamic stability and movement patterns associated with lower extremity joint injury, such lateral ankle sprain (LAS) and chronic ankle instability (CAI), may trigger cartilage degeneration with consequent deteriorations in physical activity and health-related quality of life. Control theory techniques where features like natural frequencies, dampening ratios and time constants may offer the ability to quantify dynamic stability during a jump landing activity. These techniques indicate the ability to tolerate greater oscillations and the ability to attenuate joint oscillations, respectively, to determine the system stability. However, dynamic stability in the ankle has not been investigated in patients with CAI using natural frequencies, dampening ratios and time constants. Using these novel control theory techniques to assess dynamic joint stability may be able to help clinicians develop better tools to help mitigate subsequent injuries. **Objective:** Develop patient-specific mathematical models of individuals to evaluate differences in ankle joint stability between individuals with CAI, LAS-Coper, and healthy controls. **Design:** Case-control study. **Setting:** Research Laboratory. **Patients or Other Participants:** Twenty participants with self-reported CAI (2M, 18F; 23.9 ± 3.80 yrs; 166.75 ± 7.81 cm; 74.05 ± 15.87 kg), 17 LAS-Copers (2M, 15F; 23.94 ± 5.81 yrs; 165.18 ± 7.73 cm; 66.34 ± 13.33 kg), and 14 healthy controls (8M, 6F; 21.29 ± 1.94 yrs; 171.18 ± 7.05 cm; 72.51 ± 15.16 kg) volunteered. **Interventions:** Participants performed 5 vertical jumps with single-leg landings. Kinematics

and kinetics were collected using a passive retroflective marker motion capture system interfaced with force platforms. **Main Outcome Measures:** Sagittal-plane ankle kinematics were analyzed from an initial foot contract (IC) to 100ms post-IC. The sagittal plane jump landing ankle waveform was fit to the transient response of a second-order system for a step input. To evaluate dynamic stability at the ankle joint, we computed the natural frequencies, dampening ratios, and time constant. Separate one-way ANOVAs were used to assess group-differences in the natural frequencies, dampening ratios, and time constant. Tukey's post hoc testing was conducted as needed. Significance was set a priori at $P < 0.05$. **Results:** There were significant group-differences in natural frequency responses ($P = 0.003$). The control group had the highest natural frequencies (12.4 ± 11.2), followed by the CAI (8.5 ± 10.6, $P = 0.11$), and then the LAS-Coper groups (4.3 ± 3.6, $P < 0.001$). No differences in natural frequency were observed between the CAI and control groups ($P = 0.09$). Neither mean dampening ratios ($P = 0.09$) nor time constants ($P = 0.17$) were significantly different between groups ($P > 0.05$). **Conclusions:** All three groups adopted different ankle strategies to achieve stable biomechanics. The higher natural frequencies in the control group indicated that they can tolerate higher joint oscillations compared to individuals with CAI and LAS-Copers. This control technique may enable clinicians to track individual ankle stability during the rehabilitation process. Future work needs to determine if these changes reflect an inability to control joint motion in specific frequency ranges or if the response is a compensatory and/or protective mechanism.

The Effects of Visual Feedback and Ankle Laxity on Dynamic Balance in Trained Ballet Dancers

Miller HN, Felpel ZJ, Stirling AS, Bengtson EN, Needle AR: Appalachian State University, Boone, NC; Transylvania Regional Hospital, Brevard, NC; Orthopedic Associates of Lancaster, Lancaster, PA; Belmont University, Nashville, TN

Context: Dynamic postural control is dependent on sensorimotor integration of proprioceptive, visual, and vestibular information to correctly regulate muscle activity and maintain balance. Dynamic stability is especially crucial in dance and ballet, where single-leg stabilization is frequently required. Among ballet dancers, the capacity of dynamic postural control mechanisms may be modified by both intrinsic factors (laxity) and extrinsic factors (mirror feedback); however, these relationships are not well understood. **Objective:** This study aimed to evaluate ankle laxity and dynamic stability in ballet dancers during a hop-to-stabilization task with and without mirror feedback. **Design:** Repeated-measures design. **Setting:** University laboratory. **Patients or Other Participants:** Fifteen ballet dancers (21.3 ± 5.3 yrs, 164.6 ± 8.2 cm, 59.6 ± 7.3 kg) volunteered for this study. Participants were free of injury for 12 months prior to testing, and reported at least 5 years of ballet training (mean $= 16.3 \pm 6.5$ yrs). **Interventions:** Ankle laxity was assessed using an instrumented ankle arthrometer. Five anteroposterior translations (AP) and inversion-eversion rotations (IE) were applied to 130N and 4.2Nm, respectively. Dynamic stability was assessed using a hop-to-stabilization task. Electromyography sensors were placed over the tibialis anterior (TA), peroneus longus (PL) and lateral gastrocnemius (LG) of a randomly selected leg. Participants were then asked to perform a 2-step approach and hop over a 15cm hurdle placed a distance of 100% leg length from a force plate. Upon landing, participants were asked to maintain single-leg balance for 10-seconds. A total of 5 hops with and without mirror feedback were performed in a randomized order. Forces and electromyography were simultaneously collected in custom software at 1000 Hz. **Main Outcome Measures:** AP displacement (mm) and IE rotation (°) were extracted from arthrometer data. Time-to-stabilization (TTS) was quantified as the time for each ground reaction force component to reach a stable state after landing on a force plate. Electromyography was filtered and rectified to establish a linear envelope, and mean activation was determined 250ms prior to and after landing. Differences between mirrored and non-mirrored conditions were assessed using factorial analysis of variance, and relationships between laxity and TTS were assessed with Pearson correlations ($\alpha = 0.05$). **Results:** No significant effects of the mirror were detected for TTS measures ($F = 0.105$, $p = 0.900$; mirror $= 3.31 \pm 0.10$ s; no-mirror $= 3.37 \pm 0.12$ s). A significant time-by-mirror interaction effect was detected for EMG activity ($F = 5.006$, $p = 0.014$); however, post-hoc tests revealed no differences between mirror and no-mirror conditions at any time ($p \geq 0.055$). Correlations were observed between AP laxity and forward TTS with mirror ($r = 0.655$, $p = 0.008$), and between AP laxity and horizontal TTS without mirror ($r = 0.858$, $p < 0.001$). **Conclusions:** Dynamic balance in ballet dancers was not affected by mirror feedback in this study; however, ankle laxity was demonstrated to predict dynamic stability, as participants with more laxity had worse dynamic balance, although this relationship was affected by the presence of the mirror.

Heat Best Practices Forum: Exertional Heat Illness in Younger Athletes

Tuesday, June 27, 2017, 8:15AM-9:15AM, Room 370; Moderator: Susan Yeargin, PhD, ATC; Discussants: Rebecca Lopez, PhD, ATC; Brendon McDermott, PhD, ATC

Implementation of Heat Acclimatization Policies in Secondary School Athletics

Adams WM, Scarneo SE, Stearns RL, Casa DJ: Korey Stringer Institute, Department of Kinesiology, University of Connecticut, Storrs, CT

Context: Heat acclimatization is a term used to describe the physiological adaptations occurring over a period of 10-14 days that improve one's tolerance to exercise in the heat. This is an effective strategy to minimize the risk of exertional heat stroke (EHS), with evidence demonstrating a reduction in EHS related death at the collegiate, and more recently, the secondary school level when implemented. However, the adoption of evidence-based heat acclimatization guidelines at the secondary school level is currently unknown. **Objective:** To determine the extent of state high school athletics associations (SHSAAs) that requires pre-season heat acclimatization policies that meet current evidence-based minimum best practice recommendations. Additional consideration is given to state legislation if it also enforces these guidelines. **Design:** Descriptive observational study. **Setting:** Secondary school athletics. **Patients or Other Participants:** State High School Athletics Associations **Data Collection and Analysis:** Seven recommendations for meeting minimum best practices for heat acclimatization were derived from the 2009 consensus statement for heat acclimatization in secondary school athletics. An extensive review of SHSAA handbooks, constitutions, bylaws, policies and procedures, SHSAA websites, and enacted state legislation was performed for the academic year 2015-2016 to identify the inclusion of the aforementioned recommendations into mandated policies for the member schools governed by the SHSAA. Frequencies were tabulated for each recommendation. These are presented as a representative sample of the United States and District of Columbia. Percent improvement from the 2014-2015 academic year by individual recommendation was also calculated. **Results:** Of all 51 SHSAAs, 18 (35%; 17 states and the District of Columbia) currently meet all seven evidence-based minimum best practices for heat acclimatization. Of all SHSAAs, 55% of SHSAAs comply with the recommendation that protective equipment (if applicable to the sport) should be phased in over the course of the first six days; a 20% improvement from the 2014-2015 school year. Forty-nine percent of SHSAA meet the recommendation that total practice time should not exceed three hours in any one day practice; a 20% improvement from the 2014-2015 school year. Only 37% and 43% of SHSAAs meet the recommendation that double day practices must alternate with single day practice starting on day six and that total practice time on a double day practice must not exceed a total of five hours (or 3 hours within a single session); a 9% and 15% improvement from the 2014-2015 school year respectively. **Conclusions:** Only 35% of SHSAAs require their member schools to implement the NATA heat acclimatization policy, however many demonstrated improvement on individual recommendations. Given that the implementation of these guidelines have demonstrated a reduced risk for EHS related death, further efforts are needed to have the remaining states fully adopt these policies to potentially avoid any future deaths.

The Effect of Environmental Heat Stress on Functional Balance in Firefighters

Winkelmann ZK, McGinnis KD, McAdam JS, Pascoe DD, Sefton JM, Games KE: Tactical Athlete Research and Education Center, Indiana State University, Terre Haute, IN; Warrior Research Center, Auburn University, Auburn, AL

Context: Firefighters must perform their job duties in sustained temperatures of 80-150°C. Currently, heat stress is considered the primary source of fatigue and the link between firefighting tasks and musculoskeletal injuries. There is a lack of research examining the relationship between environmental heat exposure and functional balance deficits. **Objective:** To investigate the functional balance of firefighters following a bout of standing in a hot, humid environment. **Design:** Repeated measures, single cohort. **Setting:** Environmental chamber (Wet Bulb Globe Temperature = 37.9 ± 0.6°C). **Patients or Other Participants:** Thirteen male career firefighters (age = 24.8 ± 5.6 y; height = 176.8 ± 5.1 cm; mass = 83.8 ± 11.2 kg; years of experience = 6.1 ± 5.4 y) not on restricted duty. **Interventions:** Participants donned firefighter turnout gear (mass of turnout gear = 22.6 ± 0.7 kg). Participants completed eight trials of the modified Functional Balance Test (mFBT) which included an overhead obstacle, steps up and down, and turns in a defined space. Participants stood in the environmental chamber without access to water for 40 minutes or until core temperature reached 40.0°C. After environmental exposure, participants again completed the mFBT. Participants completed a 20-minute recovery period followed by a final mFBT. Core temperature and perceived exertion (RPE) were measured after each mFBT testing period. **Main Outcome Measures:** The independent variable included time (pre-intervention, post-intervention, and post-recovery).

Dependent variables included core temperature (°C), RPE (points), and the mFBT performance time (s), errors (points), and performance index. We conducted multiple one-way ANOVAs and post-hoc analyses. **Results:** Mean core temperature and perceived exertion both elevated during heat exposure (pre-intervention = 37.7 ± 0.3°C, 8.4 ± 1.9 pts; post-intervention = 38.1 ± 0.3°C, 11.9 ± 4.2 pts) and returned to baseline following recovery (post-recovery = 37.5 ± 0.8°C, 8.2 ± 1.6 pts). There was a significant time effect on mFBT performance times (Wilks' $\Lambda = 0.364$, $F_{(2,11)} = 9.608$, $p = 0.004$, $\eta^2 = 0.636$). Pairwise comparisons found significant differences between pre-intervention and post-recovery measures (mean difference (MD) = 0.80, 95% CI = 0.27-1.33, p = 0.007) and post-intervention and post-recovery measures (MD = 0.59, 95% CI = 0.27-0.90, p = 0.001). No significant effect of time existed for mFBT minor errors (Wilks' $\Lambda = 0.673$, $F_{(2,11)} = 2.672$, $p = 0.113$, $\eta^2 = 0.327$). Pairwise comparisons found a significant difference between pre-intervention and post-intervention measures (MD = -0.18, 95% CI = -0.35-0.02, p = 0.035). No significant effect of time existed for mFBT major errors (Wilks' $\Lambda = 0.723$, $F_{(2,11)} = 2.106$, $p = 0.168$, $\eta^2 = 0.277$). There was a significant time effect for mFBT performance index scores (Wilks' $\Lambda = 0.146$, $F_{(2,11)} = 32.278$, $p < 0.01$, $\eta^2 = 0.854$). Pairwise comparisons found a significant difference between pre-intervention and post-recovery measures (MD = 0.83, 95% CI = 0.35-1.32, p = 0.003) and post-intervention and post-recovery measures (MD = 0.86, 95% CI = 0.61-1.10, $p < 0.01$). **Conclusions:** A 40-minute exposure to environmental heat does not decrease the functional balance in firefighters. Participants completed the mFBT faster with more errors following the environmental exposure compared to a slower performance with fewer errors prior to exposure. These data suggest that heat stress may cause a reactionary response to finish the tasks more quickly than safely. Future research should explore the effect of work, in addition to environmental heat on functional balance.

Thermoregulatory and Perceptual Effects of a Percooling Garment Worn Underneath an American Football Uniform

Keen ML, Miller KC, Zuhl MN: Central Michigan University, Mt. Pleasant, MI

Context: American football uniforms impair heat dissipation and increase metabolic heat production thereby increasing athletes' risk of developing exertional heat illnesses (EHI) and dehydration. Percooling (i.e., cooling during exercise) garments may help prevent EHI by mitigating hyperthermia and dehydration. Few authors have investigated percooling garments effect on perceptual and physiological variables in individuals exercising in the heat while wearing American football uniforms. **Objective:** Determine if wearing percooling garments (QorePerformance Inc., McLean, VA) affected physiological or perceptual measurements of humans wearing American football uniforms during and after exercise in the heat. **Design:** Cross-over, counterbalanced, randomized, repeated-measures study. **Setting:** Laboratory. **Patients or Other Participants:** Twelve physically-active males (age = 24 ± 4 y, mass = 80.1 ± 8.5 kg, height = 182.5 ± 10.4 cm, body fat = 13 ± 5%, body surface area = 2.01 ± 0.15 m2). **Interventions:** On day 1, we measured participants' peak oxygen consumption (VO2) during a graded treadmill exercise test. On days 2 and 3, we measured urine specific gravity (USG) and nude body weight. Participants donned percooling garments (spandex shorts and arm bands with pockets for re-usable ice packs covering the femoral and brachial arteries) and a full American football uniform. They completed three, 20-minute bouts of exercise (~33°C, ~42% relative humidity). On day 2, treadmill grade and speed were recorded and adjusted every 5 minutes so participants exercised at ~50% of VO2. Treadmill grades and speeds were matched on day 3. Participants exercised with (ICE) or without (control) ice packs in the garments. Ice packs were replaced every 20 minutes on ICE day. Following the last exercise bout, participants rested 15 minutes; were weighed nude; and USG was re-measured. **Main Outcome Measures:** Rating of perceived exertion (RPE), thermal sensation, and thirst sensation were measured before and after each exercise bout. Environmental symptom questionnaire (ESQ) responses, nude body weight, and USG were measured pre and post-exercise. Trec, HR, and VO2 were measured every 5 minutes. We calculated change in HR (ΔHR) and Trec (ΔTrec). Sweat rate, sweat volume, and percent hypohydration were calculated from body mass. Means ± SD were calculated. Repeated measures analysis of variance with Tukey-Kramer post-hoc tests or dependent t-tests were used to identify differences between conditions over time. **Results:** No interactions ($F_{17,187} \leq 1.6$, $P \geq 0.1$) or main effect of cooling condition ($F_{1,11} \leq 1.4$, $P \geq 0.26$) occurred for ΔTrec, ΔHR, thermal sensation, thirst, RPE, ESQ responses, and USG. No differences occurred for sweat volume ($t_{11} = 0.68$, $P = 0.26$), sweat rate ($t_{11} = 0.68$, $P = 0.26$), and percent hypohydration ($t_{11} = 0.7$, $P = 0.25$). VO2 differed between conditions over time ($F_{15,165} = 3.3$, $P < 0.001$); ICE was lower than control at 30, 55, and 70 minutes ($P < 0.05$). **Conclusions:** It is unlikely these garments would prevent EHI or minimize dehydration in American football athletes. Clinically insignificant changes in VO2 occurred within the first 5 minutes post-insertion of ice packs. Ineffectiveness can be primarily attributed to the small body surface area treated and ice pack size.

Physiological and Perceptual Effects of Repeated Exercise Bouts in Heat

Pryor RR, Pryor JL, Vandermark LW, Adams EL, VanScoy RM, Casa DJ, Armstrong LE, Maresh CM, Lee EC, Anderson JM: Korey Stringer Institute, Department of Kinesiology, University of Connecticut, Storrs, CT; Central California Sports Sciences Institute, California State University, Fresno, CA

Context: Current secondary school guidelines recommend conducting only one practice session per day during the first 5 days of summer preseason practice with multiple practice sessions per day beginning on day six. However, these recommendations are not always followed, possibly increasing the risk of heat illnesses during the first week of practice. **Objective:** To 1) determine if one bout of strenuous exercise in heat affects thermal and cardiovascular strain during a subsequent exercise bout the same day, and 2) determine if multiple exercise bouts in the heat affect thermal and cardiovascular strain during exercise the subsequent day. **Design:** Observational study. **Setting:** Research laboratory. **Patients or Other Participants:** Eighteen non-heat acclimated male volunteers (age = 22 ± 3 y, height = 180.0 ± 6.0 cm, weight = 74.24 ± 7.42 kg, body fat = 9.4 ± 4.1%, maximal oxygen consumption [VO2max] = 54.6 ± 5.1 ml·kg-1·min-1). Interventions: Subjects underwent two exercise bouts on the first day (Bout 1 and Bout 2) separated by 120 min of rest in a thermoneutral environment and one exercise bout the following day (Day 2) in oppressive environmental conditions (40°C, 40% relative humidity). Each exercise bout consisted of intermittent treadmill exercise (six 20 min cycles of walking [4 min], jogging at 60% VO2max [8 min], running at 80% VO2max [3 min], and seated rest [5 min], totaling 120 min). **Main Outcome Measures:** Heart rate (HR), rectal temperature (Tre), and perceptual measures (thirst, thermal sensation, fatigue, and rating of perceived exertion [RPE]) were assessed throughout exercise. A priori paired samples t-tests compared variables between bouts and days at similar time points. **Results:** 100%, 39%, and 72% of participants completed the full 120 min exercise protocol during Bout 1, Bout 2, and Day 2, respectively. Resting HR and Tre were lower before Bout 1 (80 ± 12 bpm; 36.79 ± 0.44°C) than Bout 2 (103 ± 17 bpm, $p < 0.001$; 37.06 ± 0.50°C, $p = 0.038$) but were similar to Day 2 (81 ± 13 bpm, $p = 0.728$; 36.80 ± 0.32°C, $p = 0.924$), respectively. Fatigue was lower before Bout 1 than both Bout 2 ($p < 0.001$) and Day 2 ($p = 0.012$). Immediate post-exercise (IPE) HR, Tre, thirst, and fatigue were similar between Bout 1, Bout 2, and Day 2 ($p > 0.05$) despite a shorter exercise duration during Bout 2 (93 ± 27 min, $p < 0.001$) and Day 2 (113 ± 12 min, $p = 0.032$) compared to Bout 1 (120 ± 0 min). IPE thermal sensation and RPE were lower after Bout 1 than Bout 2 ($p = 0.043$; $p = 0.042$) but were similar to Day 2 ($p = 0.185$; $p = 0.837$), respectively. **Conclusions:** The second of two exercise bouts on the same day resulted in greater cardiovascular strain, thermal strain, and fatigue prior to exercise. Exercise ceased prematurely during both Bout 2 and Day 2. Medical staff and coaches should avoid multiple practices on the same day within the first week of practice to mitigate increased fatigue and physiological strain during subsequent exercise bouts.

The Difference in Core Temperature and Heart Rate Between Collegiate American Football Backs and Linemen During Pre-Season

Ward BP, Fowkes Godek S, Chlad PS, Feairheller DL, Morrison KE: West Chester University, West Chester, PA; Ursinus College, Collegeville, PA

Context: Current literature suggests that core temperature (Tc) and heart rate (HR) are positively correlated and that anthropometric variables influence each. Patterns for these variables during pre-season have not been widely examined and few have included comparisons of American football backs (BKs) versus linemen (LM). **Objective:** To evaluate the differences in Tc and HR in American football BKs and LM **Design:** Observational Cohort **Setting:** Data was collected at an NCAA Division III University during pre-season **Patients or Other Participants:** Twenty Division III football players volunteered for this study and were separated into groups: 11 BKs [age: 20.2 ± 0.75 y, mass: 90.2 ± 6.9 kg, height: 180.6 ± 5.9 cm, BSA/mass: 233.9 ± 10.8 cm2, VO2peak: 48.9 ± 4.9 ml/kg*min] and 9 LM [age: 20.6 ± 0.7 y, mass: 110.6 ± 13.2 kg, height: 182.6 ± 4.7 cm, BSA/mass: 209.9 ± 12.9 cm2, VO2peak: 42.4 ± 5.4 ml/kg*min]. **Interventions:** VO2peak testing was performed the week prior to the beginning of pre-season. We monitored Tc and HR via ingestible sensors and Polar© heart rate straps every 15 min during practices on day 2(D1), day 3(D2), day 4(D3), day 5(D4) and after acclimatization on day 11(D5). Wet bulb globe temperature (WBGT) was recorded on each collection day. The primary aims were analyzed using separate 2 group (position) by day repeated measures ANOVA as well as multiple independent and paired t-tests and Pearson's correlations ($\alpha = 0.05$). **Main Outcome Measures:** Tcmax, BSA/mass, VO2peak, HRmax,

ΔTc (max-min), ΔHR (max-min). **Results:** There was a significant difference in BSA/mass (cm2) between BKs (233.9 ± 10.8) and LM (209.95 ± 12.99), $p < 0.005$. VO2peak (ml/kg*min) was higher in BKs (48.9 ± 1.5) vs. LM (42.4 ± 5.4), $p = 0.012$. Overall Tcmax (D1-5) was higher in LM (39.1 ± 0.19°C) vs. BKs (38.8 ± 0.36°C), $p = 0.036$. There was a significant group by day (D1-5) interaction in ΔTc $F(3.09,3.11) = 3.63$, $p = 0.017$, indicating that the pattern of Tc variability during practice was different across days between groups. Post-hoc analysis revealed that BKs had significantly ($p = 0.02$) higher ΔTc values on D1 (3.47 ± 1.23°C) compared to LM (2.34 ± 0.69°C). On D4, the ΔTc was lower in the BKs (2.59 ± 0.71°C) compared to LM (3.24 ± 0.79°C), but did not reach significance ($p = 0.11$). With groups combined there was a moderate positive correlation on D2 between the ΔTc (2.64 ± 0.66 °C) and ΔHR (80.2 ± 14.2 bpm), $r = 0.516$, $p = 0.02$. **Conclusions:** The results of this study suggest that LM are significantly less fit than BKs and have a lower BSA/mass ratio. Overall, LM generated higher Tcmax values across the first 4 days of pre-season. Change in Tc varied across day between groups. The smaller, fitter BKs had greater variability in Tc on D1 and less on D4 compared to LM. Specifically, D4 had a high WBGT (34.16°C), was the introduction of full-padding, and was when the LM had the highest Tcmax values (38.8 ± 0.25°C) and second highest HRmax (157.14 ± 13.87 bpm). This suggests that the position may impose greater thermoregulatory demands once full pads are worn, compared to BKs.

Repeated Exertional Heat Stroke Incidence in a Warm-Weather Road Race

Stearns RL, Hosokawa Y, Adams WM, Belval LN, Huggins RA, Jardine JF, Katch RK, Davis RJ, Casa DJ: Korey Stringer Institute, Department of Kinesiology, University of Connecticut, Storrs, CT; Falmouth Hospital, Falmouth, MA

Context: Previous research suggests that exertional heat stroke (EHS) survivors may be more susceptible to subsequent EHS or heat-related illness. Alternatively, it is theorized that some individuals are simply at higher risk for EHS due to inherent physiological factors rather than an initial EHS insult. Limited research exists to determine the extent of repeated EHS in an otherwise healthy population. **Objective:** To evaluate the incidence of repeated EHS cases for participants running in a warm-weather road race. **Design:** Incidence study via medical record review. **Setting:** Fourteen consecutive years between 2003-2016 at the Falmouth Road Race (11.3 km, Falmouth, MA). **Patients or Other Participants:** A total of 133,132 finishers and 160 EHS patients were included in the analysis. Interventions: Interventions: Medical records of EHS patients from the race were obtained and analyzed for previous medical history and treatment of EHS or repeated EHS (EHSr) across years. **Main Outcome Measures:** Incidence of EHSr by successful finishers and average EHSr cases per patient were evaluated. Descriptive statistics include age, finish time, sex, initial rectal temperature (Tre), subsequent EHS Tre, and years between EHS cases. **Results:** A total of 11 patients (7 males, 4 females, age = 35 ± 14 yr) were identified as EHSr. These 11 patients represented 7% of the total EHS cases (n = 26/160 EHS cases) and had an average of 2.4 EHS cases per person (range = 2-3). This resulted in an average of 1.8 ± 1.3 EHSr per year. Accounting for the 75 total races completed by EHSr, the overall incidence rate was 3.3 EHSr per 10 races (or 35% for EHSr). EHSr completed 33 of the 75 races (44%) without EHS incident in a subsequent year following EHS diagnosis. The average initial Tre was 41.4 ± 0.7°C. First documented EHS Tre was 0.4 ± 1.0°C higher than subsequent EHSr Tre. Average finish time was 52.2 ± 8.9min, subsequent finish times with EHSr were 3.4 ± 5.0 min slower than initial EHS finish times. The number of years between first and second EHS was 3.0 ± 3.0 yr, range = 1-11 yr, mode = 1 yr. **Conclusions:** Though only a preliminary analysis, these results suggest that 7% of yearly EHS cases at this particular road race are patients who have been previously treated for EHS at the same race. While repeated cases of EHS demonstrate that patients have an overall slower finish time and lower Tre, EHSr patients also demonstrated a large ability to return and successfully complete subsequent years of the same race. Future research should continue to collect information on these cases to examine factors or biomarkers that could explain individuals who are susceptible to EHSr, such as a genetic variants or incomplete recovery, and corresponding prevention strategies.

Free Communications, Oral Presentations: Lower Extremity Mechanics, Function and Overuse Injury

Tuesday, June 27, 2017, 11:15AM-12:45PM, Room 370; Moderator: Scott Ross, PhD, ATC

Trunk and Lower Extremity Movement Patterns and Stress Fracture Risk Factors Influence Biomarkers of Bone Turnover During Cadet Basic Training

Mauntel TC, Marshall SW, Hackney AC, Pietrosimone BG, Cameron KL, Peck KY, Trump JR, Padua DA: Walter Reed National Military Medical Center, Bethesda, MD; University of North Carolina, Chapel Hill, NC; Keller Army Hospital, United States Military Academy, West Point, NY

Context: Lower extremity stress fractures (SFx) affect 1-in-3 male military service members and significantly impact military readiness. Movement patterns, physical fitness, and previous physical activity and injury affect SFx risk. Bone biomarker turnover ratios (i.e., formation-to-resorption) have potential utility in tracking changes in bone health. **Objective:** To determine if SFx risk factors influence bone biomarker turnover ratios. **Design:** Cross-sectional. **Setting:** US Service Academy. **Patients or Other Participants:** 45 male cadets (age pre = 18.56 ± 1.39 yr; height pre = 176.95 ± 7.29 cm; mass pre = 77.20 ± 9.40 kg; BMI pre = 24.68 ± 2.87) who completed Cadet Basic Training (CBT). Cadets with neurological or metabolic disorders were excluded. **Interventions:** We assessed SFx risk factors (independent variables), with: 1) a movement assessment; 2) self-reported injury and physical activity questionnaires; and 3) physical fitness tests. Bone biomarkers (dependent variables; formation: procollagen type I amino-terminal propeptide [PINP], resorption: cross-linked collagen telopeptide [CTx-1]) were assessed via a serum sample. **Main Outcome Measures:** A markerless motion capture system analyzed trunk and lower extremity movement patterns during 3 jump-landing trials via the Landing Error Scoring System (LESS). Serum samples were collected post-CBT. ELISAs determined PINP and CTx-1 serum concentrations; biomarker turnover ratios (PINP:CTx-1) were calculated. A parsimonious multivariate linear regression model ($\alpha \leq 0.05$), including only significant predictors identified by univariate linear regression models ($\alpha \leq 0.10$) determined the predictability of LESS items and other SFx risk factors. Mean differences (μdiff) and associated 95% confidence intervals (95% CI) were calculated. **Results:** The multivariate model incorporating LESS data and other SFx risk factors predicted PINP:CTx-1 (R2 = 0.66, p = 0.01). PINP:CTx-1 was influenced by: foot internal rotation (μdiff = 0.46, 95% CI: 0.24,0.87; p = 0.02); excessive trunk flexion displacement (μdiff = 1.45μg/L, 95% CI: 0.98,2.14; p = 0.07); and injury during CBT (μdiff = 0.46, 95% CI: 0.29,0.73; p < 0.01). No other significant predictors were identified. **Conclusions:** Lower extremity SFx risk factors accounted for 66% of the variability of the post-CBT PINP:CTx-1 ratios, a potential surrogate for bone health. Foot internal rotation, excessive trunk flexion, and injury during CBT increased PINP:CTx-1 ratios; these variables increased PINP concentrations but had no effect of CTx-1 concentrations. Foot internal rotation commonly occurs in conjunction with foot plantar flexion during jump-landings. Foot plantar flexion can help dissipate ground reaction forces and thus more bone formation can occur opposed to bone resorption. Similarly, trunk flexion displacement dissipates ground reaction forces and would have similar effects on bone turnover. Injury during CBT resulted in larger PINP:CTx-1 ratios, this was a surprising finding. One plausible explanation is that the injury occurred early enough in CBT that the acute breakdown of collagen fibers had ended and that new collagen was rebuilding, thus larger PINP:CTx-1 ratios were observed. Our findings provide insight into how SFx risk factors influence bone health. This information can help guide SFx risk mitigation strategies.

Influence of Anterior Knee Pain With/Without Structural Patellar Tendon Damage on Arthrogenic Muscle Inhibition

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Context: Pain is often reported as a main cause of quadriceps arthrogenic muscle inhibition (AMI). While previous work has found that pain negatively influences quadriceps volitional muscle control, studies examining this relationship have done so using induced effusion or included patients with a history of knee surgery. Given the confounding effects of these models, the true influence of pain on quadriceps muscle function is unknown. Ascertaining if persisting pain alone contributes to a neurological shut down of the muscle is critical to understanding the role of pain in neuromuscular dysfunction. Anterior knee pain (AKP) and structural patellar tendon (PT) damage provide a framework to examine the complex relationships between tissue damage, pain and AMI. **Objective:** To compare measures of AMI in cases of AKP with or without diagnostic evidence of structural PT damage to determine whether pain alone contributes to quadriceps AMI. **Design:** Case-control **Setting:** Laboratory **Patients or Other Participants:** 9 participants who scored below 80 on the Victorian Institute of Sport Assessment: Patellar questionnaire, were recruited (6 males, 3 females, 21.11 ± 1.17 yrs, 1.78 ± 0.08 m, 74.22 ± 7.22 kg,VISA-P: 59.56 ± 16.35). Knees were classified as having structural PT damage if ultrasound imaging displayed hypoechoic lesions and/or neovascularization (n = 5). All other knees were classified as AKP (n = 13). **Interventions:** Participants completed one testing session where measures of the Hoffmann's Reflex normalized to

the muscle response (H:M ratio) and central activation ratio (CAR) calculated using the superimposed burst technique were measured in both limbs. **Main Outcome Measures:** Differences in CAR and H:M ratio were compared between structural PT damage and AKP knees using Mann Whitney U tests ($\alpha < 0.05$). **Results:** Knees with structural PT damage displayed significantly lower CAR (92.04 ± 5.00, U = 5.00, P = 0.007) and H:M ratio (0.09 ± 0.04, U = 8.00, P = 0.016) compared to AKP knees (CAR: 98.10 ± 0.97; H:M ratio: 0.31 ± 0.23). In the patient suffering from bilateral pain and unilateral structural PT damage (n = 1), deficits in CAR (AKP knee: 96.65; PT knee: 91.47) and H:M (AKP knee: 0.17; PT knee: 0.03) were only idenitifed on the leg affected by structural PT damage. **Conclusions:** Knees with structural PT damage demonstrated reduced volitional muscle activation and alterations in afferent pathways of AMI. In contrast, knees with only AKP demonstrated levels of quadriceps neural activity that are equal to that of healthy normative values. Taken together, these data lead us to believe that structural damage, potentially originating from altered mechanoreceptors, not pain, is primarily responsible for quadriceps AMI in this population. Continued investigation is needed in order to confirm these relationships but our findings may have important implications for clinical care of athletes suffering knee pain.

The Effect of a 4-week Short-foot Exercise on Gait Characteristics in Patients with Stage II Posterior Tibial Tendon Dysfunction

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Context: Not only foot structural changes but also abnormal activation and demand in extrinsic foot muscles have been observed in patients with stage II posterior tibial tendon dysfunction (PTTD). Clinically, it has been suggested that increased activation of foot core muscles may alter activation demand of extrinsic muscles surrounding ankle joint in stage II PTTD. However, there are limited number of empirical evidence to support this notion. **Objective:** To investigate the effect of a 4-week short-foot exercise (SFE) as neuromuscular exercise of foot core muscles on foot biomechanics in stage II PTTD patients. **Design:** Pretest-posttest study. **Setting:** Research laboratory. **Patients or Other Participants:** Fifteen subjects with stage II PTTD were voluntarily recruited for this study (8M, 7F; VAS pain (%): 77.18 ± 12.44; FPI score: 9.20 ± 1.42; ND: 13.10 ± 2.54). The inclusion criteria were individuals to have pain in posterior tibial tendon, pronated foot deformity (Foot Posture Index score ≥+6), and flexible foot deformity (navicular drop ≥10mm). **Interventions:** All subjects completed a 4-week SFE program (15 rep/3 set/day, 3 days/week). Progression for SFE included standing with assistance of neuromuscular electro-stimulator (NMES), sitting, double and single-leg standing position without NMES. Progression to the next level was determined based upon subjects' ability to complete the task. **Main Outcome Measures:** Ankle joint kinematics and moment, and activation (%MVIC) of tibialis anterior (TA) and peroneus longus (PL) muscles during walking (3miles/hr) were measured before and after exercise. The kinematic data were separated into three rockers to provide a comprehensive comparison of the differences in stance phase. Moment and EMG values at peak kinematic values were extracted for further analysis. Cohen's d effect size [ES (95%CI)] was calculated to identify magnitude of the difference. **Results:** In first rocker, TA activation was significantly decreased at peak plantarflexion [ES = 0.75 (0.64-0.85)] and inversion [ES = 0.87 (0.12-1.61)] angle. In second rocker, peak dorsiflexion angle [ES = 0.38 (0.03-1.51)] and TA activation at peak eversion [ES = 1.57 (0.76-2.39)] were significantly reduced. In third rocker, peak abduction angle [ES = 0.80 (0.06-1.54)], TA and PL activation at peak plantarflexion [ES = 1.34 (0.55-2.13); ES = 1.99 (1.11-2.86)] and peak abduction [ES = 1.29 (0.50-2.07); ES = 1.67 (0.84-2.50)] were significantly decreased. **Conclusions:** The results from this study suggest that the reduction in activation of TA and PL with similar kinematics and moment after intervention can be potential benefits to decrease TP activation after SFE. However, direct measurement of TP should be conducted to guarantee the effectiveness of SFE. Therefore, further study is essential to investigate the change of TP and intrinsic muscle directly to use indwelling EMG.

Relationship of Running Biomechanics with Hip Strength and Trunk Endurance

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Context: Female runners with chronic lower extremity injury often demonstrate altered running biomechanics at the hip, pelvis and trunk, as well as decreased isometric hip abduction (HABD) and external rotation (HER) strength when compared to healthy runners. Given the complexity of chronic running related injuries, we believe establishing the relationship between running biomechanics, isometric strength, and trunk endurance in healthy runners will assist with developing the most impactful treatment interventions in pathological runners. **Objective:** Investigate the relationship of frontal plane running biomechanics at the hip, pelvis and trunk with isometric hip strength and trunk musculature endurance. **Design:** Descriptive laboratory study. **Setting:** Research laboratory. **Patients or Other Participants:** Fifty healthy, female recreational runners volunteered (39.01 ± 9.44 yrs, 165.35 ± 7.43 cm, 64.78 ± 11.95 kg). **Interventions:** Three-dimensional kinematics (200Hz) and kinetics (1000Hz) were collected bilaterally during six successful trials of over-ground running at a self-selected pace. Stance phase of running was normalized to 100 frames, with 1 frame representing 1% of stance phase. Peak values were extracted for each trial and averaged across trials. Trunk flexor endurance (TFLX) was tested using a repetitive sit-up test, while trunk extension (TEXT) and lateral trunk flexion (LTFLX) endurance were performed using the modified Beiring-Sorensen test in the prone and side-lying positions, respectively. Hip extension (HEXT), HABD, and HER strength were performed in positions that are previously established in the research literature. Running trials were performed prior to strength and endurance tests to limit the effect of fatigue on testing. Pearson correlations (n=18) were performed between the 6 strength and endurance variables and the 3 kinematic angles. Both sides were tested for all bilateral measures; however, the dominant limb was used for all computations. **Main Outcome Measures:** Peak hip adduction (HADD), contralateral pelvic drop (CPD), and trunk ipsilateral lean (TIL) during stance phase were reported in degrees. Isometric HABD, HER and HEXT strength were reported in Nm/Kg*m, TFLX was reported in repetitions, and TEXT and LTFLX in seconds. **Results:** There was a weak, positive correlation between CPD (6.28 ± 2.3°) and TEXT (172.25 ± 68.05 s; $p = 0.007$, $r = 0.376$) and between CPD and HABD (1.17 ± 0.273 Nm/Kg*m; $p = 0.021$, $r = 0.325$). There was a weak, negative correlation between TIL (3.48 ± 1.35°) and LTFLX (65.05 ± 25.71 s; $p = 0.013$, $r = -0.350$). No significant relationships existed for the remaining 13 correlations ($p \geq 0.05$). **Conclusions:** This study found no significant relationship between HABD strength and peak HADD during running, and a weak correlation of CPD with both HABD and TEXT. Based on these findings, interventions that only focus on one deficiency associated with chronic lower extremity injuries may not have a strong impact on other alterations; therefore, clinicians should incorporate exercises to improve running biomechanics, strength, and trunk endurance. In addition, future research should investigate whether hip endurance rather than isometric strength plays a role in running biomechanics.

Achilles Tendon Cross Sectional Area Changes Over a NCAA Division I Cross Country Season

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Context: Changes in Achilles tendon cross sectional area may help clinicians understand exercise adaptations or Achilles tendon injury mechanisms. It is currently unknown how the Achilles tendon adapts or changes during a cross country season. **Objective:** To track adaptations in the Achilles tendon in response to an NCAA Division I cross-country season. We also determined the significance of multiple anthropometric and running variables at predicting Achilles tendon cross sectional area. **Design:** Longitudinal study. **Setting:** Musculoskeletal ultrasound images were obtained in a research laboratory. Cross country athletes ran with no restrictions outdoors and indoors. **Patients or Other Participants:** Participants were all Division I NCAA cross country athletes (N = 24, age = 19.9 ± 2.1 years, mass = 61.32 ± 20.16 kg, height = 168.92 ± 17.16 cm, gender = 8 males and 16 females, years of experience = 6.44 ± 5.54 years, years run collegiately = 2.56 ± 1.54 years). Lower leg injuries that kept an athlete from running normally for 1 week excluded that participant from the study. **Interventions:** Achilles tendon cross sectional area was obtained through musculoskeletal ultrasound imaging at a pre-season baseline measurement, then every 3 weeks throughout the season for a total of 4 measurements. Participants followed their normal running regimen outlined by their cross-country coach. **Main Outcome Measures:** The dependent variable was Achilles tendon cross sectional area measured by ultrasound imaging. Independent variables that were tracked included age, dominate vs non-dominate Achilles tendon side, time, gender, height, mass, blood type, years of running, years of running collegiately, and Achilles pain on

a 10-point numeric rating scale at the time of the image. We used a repeated measures ANOVA to determine differences in cross sectional area over the cross-country season. We used a multiple regression to determine the variance of our independent variables on cross sectional area. **Results:** Cross sectional area increased from baseline (0.439 ± .081 cm), to 0.466 ± 0.096 cm at 3-weeks, to 0.471 ± 0.092 cm 6-weeks, and decreased to 0.451 ± 0.104 cm at post-season. The 3-weeks and 6-week measures significantly increased from baseline ($F_{3,72}$ = 8.575, P < .001). A model to predict Achilles tendon cross sectional area change was created; CSA = .425-(.003•age)+(.007•side)+(.005•-time)-(.07•gender)-(.007•blood type)-(.008•years run total)+(.016•years run collegiately)-(.001•Height)+(.005•Mass)-(.017•Pain) Gender, blood type, total years running, years run collegiately, mass, and pain were significant in the model (P < 0.05). Our independent variables accounted for 73.8% of the variance in the model (R = .859, R^2 = .738). **Conclusions:** Achilles tendon cross sectional area increased during the NCAA Division I cross country season, but returned to baseline values at the end. The created predicative model can help clinicians determine changes in the Achilles tendon during a season. Future research should identify if certain Achilles tendon changes during a season become risk factors for injury.

Analysis of Plantar Fasciitis Risk Factors Among Intercollegiate and Recreational Runners: A Matched Case-Control Study

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Context: Plantar fasciitis, the most common cause of inferior heel pain, afflicts as many as 10% of the U.S. population during their lifetimes, and is currently responsible for approximately 1 million physician visits per year. Despite this prevalence, the etiology of plantar fasciitis is not well understood, particularly among physically active populations. **Objective:** To evaluate known and hypothesized risk factors for plantar fasciitis among running athletes to determine which outcome measures are most predictive of incurring this condition. **Design:** Case-control. **Setting:** Laboratory setting. **Patients or Other Participants:** 71 intercollegiate and recreational runners (40 females, 31 males) completed all aspects of this study (age, 21.8 ± 3.7 yrs; height, 168.0 ± 11.9 cm; mass, 70.3 ± 18.1 kg). We employed a 2:1 ratio of healthy runners to injured runners with plantar fasciitis for the logistic regression analysis using a subset of 63 participants, creating 21 triads that were triple matched on sex, age (+ 5 yrs), and BMI category **Interventions:** None. **Main Outcome Measures:** Dorsiflexion active range of motion (AROM), dorsiflexion passive range of motion (PROM) obtained under a constant 4.53 kg load, longitudinal arch angle (LAA), navicular drop test, lower leg and foot length, body mass index (BMI), and the Foot Function Index-Revised questionnaire score. A Group (2) x Limb (2) MANOVA was used to identify differences between the case and control groups, and the involved/uninvolved limbs (a = 0.05). Odds ratios were calculated using conditional logistic regression to identify independent risk factors for plantar fasciitis. Our secondary hypothesis investigated what extent reduced ankle dorsiflexion AROM, reduced LAA, and increased BMI were risk factors associated with the incidence of plantar fasciitis (a = 0.05). **Results:** MANOVA results indicated that dorsiflexion AROM (13.1 + 6.7 deg) and PROM (6.7+ 2.9 deg) were significantly less in the plantar fasciitis group compared to dorsiflexion AROM (17.8 + 6.9 deg) and PROM (9.6 + 3.5 deg) in the healthy control runners (P < 0.05). Injury status accounted for 16.7% and 10.6 % of the variance in dorsiflexion PROM and AROM, respectively. Results of the Cox regression analysis indicated that for the hypothesized model, decreased ankle dorsiflexion AROM, decreased LAA, and increased BMI significantly influenced the risk of incurring plantar fasciitis ($\chi 2$ = 11.05; P < 0.05). Additional analysis found that each degree of decreased dorsiflexion AROM increased the risk of plantar fasciitis by 14.6% (OR = 1.146, P = 0.013). **Conclusions:** Our findings present strong evidence of a link between limited ankle dorsiflexion and plantar fasciitis among running athletes. Future studies should involve prospective, longitudinal experimental designs with a similar population, using these same outcome measures in an effort to establish cause and effect relationships for plantar fasciitis.

Healthy Females Demonstrate Retention of Lower Extremity Biomechanical Changes Following a 4-Week Feedback Intervention Program

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Context: A quadriceps dominant landing strategy, which results in decreased knee flexion during landing could increase risk of lower extremity injury, especially in females. Increased hip and knee flexion angles can be acquired using feedback, yet it is unknown whether participants can retain changes in jump-landing biomechanics following the intervention. Retention of biomechanical changes may translate to changes in a practice or game setting, and may possibly reduce injury risk. **Objective:** To investigate the acquisition and retention of biomechanical changes made following a 4-week jump-landing feedback intervention. **Design:** Cohort Design. **Setting:** University research laboratory. **Patients or Other Participants:** Thirty-two healthy females with no history of lower extremity fracture or surgery were included in this study (N = 32; 19.6 ± 1.5 yrs; 1.63 ± 0.1 m; 58.1 ± 7.8 kg). **Interventions:** Participants completed 12 sessions over 4-weeks, during which participants performed 6 sets of 6 jumps off a 30cm box. Participants were provided verbal and visual feedback of correct landing technique following each set of jumps. **Main Outcome Measures:** Pre-intervention (PRE), following a 4-week feedback intervention (POST), and following a 1-week no feedback retention (RETENTION), participants performed three jump-landings off a 30cm box placed 50% of their height away from the target force plates and immediately upon landing, rebounded for maximum height. Peak knee and hip kinematics during the first 25% of stance were determined using standard inverse dynamics and averaged across trials. Intraclass correlation coefficients were performed to determine reliability of the measures. Separate repeated measures ANOVAs were performed, followed by paired samples t-tests to determine differences between time points. The P-value was set at $P<0.05$ for statistical significance. **Results:** Knee (ICC:0.96) and hip flexion (ICC:0.92) angles were demonstrated to be reliable in our laboratory over 4 weeks. Participants significantly increased hip flexion angles ($F_{(2,31)} = 27.3$, $P < .001$) when comparing PRE (49.0°)/POST (60.7°) ($P < 0.001$) and PRE/RETENTION (58.1°; $P < 0.001$). POST/RETENTION comparison for hip flexion angle was not significant ($P = 0.074$). Participants significantly increased knee flexion angles ($F_{(2,31)} = 26.1$, $P <.001$) when comparing PRE (73.4°)/POST (90.0°) and PRE/RETENTION (88.3°). POST/RETENTION comparison for knee flexion angle was not significant ($P = 0.24$). **Conclusions:** These results demonstrate participants were able to acquire changes in hip and knee flexion angles and retain those changes 1 week after the completion of the intervention. Participants demonstrated increased hip and knee flexion when comparing PRE/RETENTION which also provides evidence of retention following 1 week of no exposure to the feedback intervention. Increased knee and hip flexion angles could reduce risk of future lower extremity injuries, especially in females. The relationship between retention of biomechanical changes and decreased injury risk remains unknown. Future research should implement feedback with more sport-specific movements, and retention of feedback should also be investigated over a longer non-exposure period.

Effects of External Focus Feedback on Drop Landing Mechanics Transfer and Retention in Female Athletes

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Context: Anatomical, physiological and neuromuscular factors place female athletes are at higher risk of anterior cruciate ligament injury than males. Neuromuscular factors are uniquely able to be addressed with targeted motor learning interventions. Traditionally, these interventions have required trained expert clinicians to ensure quality feedback. Dyad or partner-based feedback may be a more cost-effective method to deliver movement feedback for a sports team. **Objective:** To determine the effects of dyad and expert feedback on drop landing technique retention and transfer in female athletes. **Design:** Cohort study. **Setting:** Basketball court. **Patients or Other Participants:** Twenty three healthy females (13 basketball, 10 volleyball, 19.30 ± 0.92 years, 1.72 ± 0.09 m, 68.44 ± 9.82 kg). Participants were randomly assigned to the dyad or expert feedback group (10 dyad, 13 expert). **Interventions:** A three-dimensional inertia measurement system (IMU) (Noraxon, Scottsdale, AZ) was used to capture knee kinematics of all participants at a collection rate of 200 Hz. IMUs were placed on each dorsal foot, mid-tibia, mid-thigh, sacrum, thoracic spine, and C7 spinous process. Participants performed three practice trials of the drop vertical jump before completing the baseline assessment. The drop vertical jump involved each participant falling forward from a 30cm box, then immediately performing a vertical jump, raising both arms for maximum height. A transfer and retention test was completed two weeks later. The transfer test added an in air target set at 80% of their maximum jump height (Vertec, Power Systems,

Knoxville, TN). Three landing trials at each time point were performed and averaged for analysis. **Main Outcome Measures:** Knee flexion and abduction displacement were calculated during the landing phase and compared across group, and condition (baseline, post intervention, retention and transfer test) with a repeated measures ANOVA a priori $p < .05$. **Results:** There was no effect for group for knee flexion or abduction displacement. There was a time effect with both groups significantly increasing knee flexion displacement after the intervention (3.30° ± 1.45° increase, $p = 0.035$) and no change in knee abduction displacement (0.55° ± 0.89° decrease, $p = 0.546$). There was no difference from baseline or post-intervention at the retention test for any variable, however knee flexion decreased for the transfer test (6.1° ± 2.48° decrease, $p = 0.024$) from post-intervention with no change in abduction. **Conclusions:** Dyad training induced a similar motor learning response as expert feedback with both improving knee flexion. Knee abduction displacement during landing was highly variable with some individuals (n = 12) responding with more neutral knee frontal plane displacement during landing and others having no intervention effect. This may indicate dyad feedback is a suitable alternative to the more expensive and time consuming expert feedback, making ACL injury prevention programs more accessible. The limitations of a single intervention may have reduced the capability of either intervention to cause a retention or transfer effect.

Considerations for Implementing Injury Prevention Exercises in US Marine Corps Training

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Context: Musculoskeletal injury (MSK-I) continues to be one of the largest threats to readiness in the military. Implementing injury prevention (IP) exercises is a proven method of decreasing MSK-I. Yet, in many settings, IP strategies are often implemented without understanding participants' knowledge, attitudes and beliefs (KABs) about injury prevention and causation. It is critical to have an accurate representation of participants' beliefs, motivators, and barriers towards IP to better translate research into clinically feasible practices. **Objective:** To describe KABs regarding injury and preventing injury in U.S. Marines entering training at the School of Infantry-West. **Design:** Cross-sectional survey. **Setting:** Camp Pendleton, California. **Patients or Other Participants:** Male U.S Marines entering School of Infantry-West (SOI-W) (N = 138). **Interventions:** A brief, 5-point Likert scale questionnaire regarding KABs towards lower extremity injury (LEI) was administered as part of a larger study of Marines (19.3 ± 1.4 yrs, 177.1 ± 8.1 cm, 74.0 ± 8.5 kg) entering training at SOI-W. The questionnaire was modeled off a similar survey designed to assess athletes' KABs about LEI causation/prevention. **Main Outcome Measures:** Frequencies, percentages. Responses of "agree" and "strongly agree," and "disagree" and "strongly disagree" were collapsed in to discreet categories of "agree" and "disagree," respectively. **Results:** Male Marines (n = 138) completed the KAB survey prior to beginning SOI-W training. A quarter (25.4%; n = 35) of Marines responded they believe most LEI occurring during military training are unavoidable: 31.2% (n = 43) of Marines responded that they believed training injuries are avoidable. Most Marines neither agreed nor disagreed (43.5%; n = 60) that LEIs during military training are unavoidable. Over 60% (n = 83) of Marines reported being confident they know appropriate exercises and training methods to prevent LEI, whereas 9.4% (n = 13) disagreed and 29.7% (n = 41) were neutral. Finally, 77.5% (n = 107) of Marines are willing to perform specific training and exercises to prevent injury on their own time if provided instructional resources and guidance; 21.0% (n = 29) were neutral, and only 1 Marine disagreed. **Conclusions:** Marines entering SOI-W appear to be willing to participate in IP training and report being confident they know appropriate exercises and training methods to prevent LEI. A large majority remain neutral about LEIs being unavoidable, which indicates their potential receptiveness to IP training during SOI-W. Based on these findings, we plan to develop a targeted IP curriculum to implement at SOI-W, with consideration of participants' KABs toward LEI and IP.

Athletic Trainers' Injury Prevention Practice Strategies and Barriers in Secondary Schools

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Context: Sport injuries are the leading type of injury to require medical attention and emergency department visits in the adolescent population. There is limited research on practice strategies employed to prevent injury. Objective: To explore injury prevention practice strategies and barriers faced by athletic trainers in secondary schools. **Design:** Cross-sectional. **Setting:** Web-based survey **Patients or Other Participants:** We recruited athletic trainers (n = 473/3010, 15%) in secondary schools through emails provided by the NATA. Respondents were 27.9 ± 3.4 y, predominantly female (n = 260/359, 72.4%), with about 5 years of experience (5 ± 2 y). **Interventions:** We aimed to evaluate the practice strategies and barriers to injury prevention through an electronic questionnaire. We developed the practice strategy items with tasks from Domain 1 of the Role Delineation Study (6th ed.). We developed barrier items from previous literature about implementing evidence-based practice strategies. A panel of experts (combined 60 years of experience) completed a content analysis. Based on feedback, items were edited to improve clarity. **Main Outcome Measures:** We used partial data for analysis (completion rate = 359/473, 75.9%) if more than 50% of the questionnaire was completed. The survey contained 60 items, including demographics, practice strategy items, and barrier items with available open-ended response options. Practice strategy items addressed frequency with a 4-point Likert scale (4 = always, 3 = often, 2 = sometimes, 1 = never). Barrier items addressed level of agreement with a 4-point Likert scale (4=strongly agree, 3=agree, 2=disagree, 1=strongly disagree). We analyzed the data using frequencies, medians with percentiles, means, and standard deviations. Open response items were coded independently by two researchers who came to consensus on all themes and subthemes. **Results:** Fitting protective athletic equipment (47.9%), monitoring for environmental illnesses (47.7%), addressing patient-specific nutritional needs (47.1%), and educating on accepted nutritional guidelines (43.5%) are among the least frequently practiced prevention strategies (median=2). Among the most frequently practiced prevention strategies (median=4) were collecting pre-participation screening information (61.1%), identifying (63.5%) and applying (61.3%) established guidelines and regulations, complying with manufacturer recommendations for equipment maintenance (67.4%), maintaining OSHA compliance (69.1%) and identifying non-compliance (51.5%), and recognizing malfunction of therapeutic equipment (63.8%). The most commonly cited barriers were a lack of time (3.19 ± 0.76), workload (3.07 ± 0.75), player compliance (3.08 ± 0.69), and coach support (2.87 ± 0.88). Five major barriers were identified including time (n = 131, 15.7%), personal understanding (n = 26, 3.0%), operation management (n = 214, 24.6%), communication (n = 53, 6.1%), and third parties (n = 440, 50.6%). The most common subthemes of the third party barriers included support staff (n = 147/440, 33.4%) and other party responsibility (n = 239/440, 54.3%). **Conclusions:** Respondents indicated they engaged in prevention strategies frequently. In both the barriers items and open-ended responses, participants indicated external factors, specifically third-parties, limited their abilities to apply prevention strategies. Internal factors like knowledge level or lack of preparedness were not highly rated among respondents' perceived barriers.

Knee Best Practices Forum: ACL Injury Prevention Strategies

Wednesday, June 28, 2017, 8:15AM-9:15AM, Room 370; Moderator: Barnett Frank, PhD, ATC; Discussants: Dai Sugimoto, PhD, ATC; Lindsay DiStefano, PhD, ATC

Free Communications, Oral Presentations: Breaking it Down: Loading, Degeneration, and Osteoarthritis

Wednesday, June 28, 2017, 9:30AM-10:45AM, Room 370; Moderator: Jeffrey Driban, PhD, ATC, CSCS

Differences in Functional Capacity and Subjective Symptoms Related to Joint Degeneration in Those With and Without Chronic Ankle Instability

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Context: Neuromuscular impairments surrounding the ankle are believed to contribute to cartilage degeneration in young-adults with CAI. Unfortunately, impairments associated with CAI are not confined to the ankle; rather, proximal neuromuscular alterations at the knee, thought to be responsible for reductions in knee joint health, are also found in those with CAI. While neuromuscular impairments and self-reported functional limitations have been examined in those with CAI, patient-generated symptoms associated with a decline in joint health of the ankle and knee have not been investigated. Examining self-reported function associated with a decline in joint health will help quantify further the activity limitations associated with CAI. Reduced joint health has potential to lower overall functional capacity in those with CAI, which could impact a desired healthy lifestyle. However, the functional capacity between those with and without CAI has yet to be compared. This will help further quantify the threats of CAI to the general health of individuals. **Objective:** Compare the functional capacity and perceived ankle and knee joint health in individuals with and without CAI. **Design:** Case Control Study. **Setting:** Research Laboratory. **Patients or Other Participants:** Twenty-three CAI participants, (26.45 ± 6.50 years, 166.64 ± 8.06 cm, 73.13 ± 13.23 kg) and 23 healthy controls (HC) (25.08 ± 5.47 years, 171.26 ± 9.6 cm, 70.85 ± 16.3 kg) volunteered. **Interventions:** Participants completed self-reported function questionnaires; and performed the 6-minute walk test by walking back and forth along a 30-meter indoor walkway as fast as possible for six minutes. **Main Outcome Measures:** The Ankle Osteoarthritis Scale (AOS) and the Knee Injury and Osteoarthritis Score (KOOS) assessed region specific ankle and knee function. Maximum distance walked in meters during the 6-minute test was recorded and used for statistical analysis. Mann Whitney U Tests and Cohen's d effect sizes with 95% confidence intervals (CI) were used to assess group differences in each outcome variable. Significance was set a priori at $P \leq 0.05$. **Results:** Participants with CAI walked less distance during the 6-minute walk test ($p = 0.038$ d = 0.88 [0.22,1.5]) compared to HC. Individuals with CAI reported more foot pain ($P < 0.001$, d = 0.84 [0.22,1.43]) and disability($P < 0.001$, d = 0.77 [0.16,1.36]) than HC. CAI individuals scored worse on the KOOS Symptoms ($p = 0.008$, d = 0.88 [0.26,1.47]); Pain ($p = 0.024$, d = 0.59 [-0.01,1.17]); ADL ($p = 0.013$, d = 0.55 [-0.05,1.12]); Sport & Recreation ($p = 0.002$, d = 0.96 [0.33,1.55]) and Quality of Life ($p = 0.004$, d = 0.79 [0.18,1.38]) subscales. **Conclusions:** The increased self-reported symptoms associated with a decline in ankle joint health further support recent information demonstrating cartilage degeneration in those with CAI. Though CAI is a self-reported ankle pathology, CAI participants also reported having greater self-reported knee dysfunction compared to HC. While further research is needed, these results provide preliminary evidence on the negative impact proximal neuromuscular impairments found in those with CAI may be having on more than the ankle. The reduced functional capacity further demonstrates the impact CAI has on the general health of individuals.

Greater Loading of the Reconstructed Leg is Associated With Better Patient Related Outcomes in Patients With Anterior Cruciate Ligament Reconstruction

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Context: It is unknown if asymmetry at peak vertical ground reaction force (vGRF) observed in patients with anterior cruciate ligament injury and reconstructive surgery (ACLr) is consistent across the stance phase of a jump landing, or if such an analysis would provide any greater information about patient related outcomes. **Objective:** The purpose of this study was to determine if analyzing asymmetry of vGRF across the stance phase of a jump landing provided greater insight to patient related outcomes for patients with ACLr. **Design:** Cross-Sectional **Setting:** Research laboratory **Patients or Other Participants:** Sixty-eight patients with a history of self-reported ACLr (ACLr group; Age: 18.97 ± 1.55 years, Height: 168.63 ± 7.17 cm, Mass: 68.45 ± 11.50 kg), and 75 participants without ACLr (Control group; Age: 19.80 ± 1.55 years, Height: 169.45 ± 8.12 cm, Mass: 65.35 ± 11.21 kg) participated in this study. **Interventions:** Participants performed a double leg jump landing and completed the Knee Injury and Osteoarthritis Outcome Score (KOOS). **Main Outcome Measures:** vGRF force data were recorded bilaterally during a double leg jump landing. A symmetry index was calculated at peak vGRF, and an average symmetry index was calculated across the entire stance phase. All values were normalized to body weight reported in Newtons (xBW). Each participant also completed the KOOS. Independent samples t-tests were performed to compare symmetry indexes of peak vGRF, and average symmetry

index across stance phase between groups. Pearson product-moment correlation coefficients were calculated to determine the relationship between symmetry indexes and the KOOS subscales in the ACLr group. An alpha level of 0.05 was set a-priori for all analyses. **Results:** The ACLr group demonstrated greater asymmetry (-17.09 ± 22.62 %) than the Control group (-3.35 ± 24.78 %) at peak vGRF ($t(141) = 3.45$, $p = 0.001$). The ACLr group also had greater average symmetry index (-7.33 ± 9.99 %) as compared to the control group (-1.04 ± 7.37 %) across the entire stance phase ($t(141) = 4.30$, $p < 0.001$). Symmetry index at peak vGRF was not significantly correlated with any of the subscales of the KOOS in the ACLr group ($p > 0.05$). Average symmetry index across the stance phase was significantly correlated with the KOOS subscales of ADL Score ($r(68) = 0.278$, $p = 0.022$) and Sport Score ($r(68) = 0.362$, $p = 0.002$). **Conclusions:** The negative symmetry index values for the ACLr group indicate greater loading of the unaffected leg at peak vGRF and across the stance phase. The positive linear relationship between average symmetry index and KOOS values indicate that having greater loading of the reconstructed leg across the stance phase was associated with increased ADL Score and Sport Score. This supports further analysis of asymmetry beyond discrete time points.

Comprehensive Ultrasonographic Assessment of Femoral Cartilage in Individuals With an Anterior Cruciate Ligament Reconstruction

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Context: Monitoring alterations in cartilage health following anterior cruciate ligament reconstruction (ACLR) may provide insight into the early mechanisms leading to this cohort's heightened risk of osteoarthritis (OA). Ultrasonography (US) is a valid and reliable imaging modality to assess femoral cartilage thickness. Other outcomes, such as area and echo-intensity have been assessed in other tissues and may provide important novel information regarding cartilage structure and composition, respectively. However, no study has utilized US to simultaneously assess the structure and composition of femoral cartilage following ACLR. **Objective:** To compare femoral cartilage thickness, area, average echo-intensity (echo-intensity_AVG), and echo-intensity standard deviation (echo-intensity_SD) between the reconstructed and contralateral limbs in individuals with ACLR. **Design:** Cross-sectional. **Setting:** Research Laboratory. **Patients or Other Participants:** Twenty participants with a unilateral ACLR (75% Female, 20.2 ± 2.1 years, 168.2 ± 7.3 cm, 69.7 ± 16.6 kg, 37.0 ± 26.6 months post ACLR) volunteered for this study. **Interventions:** After 30 minutes of rest in a long-sit position, a comprehensive US evaluation of the femoral cartilage was performed bilaterally in individuals with an ACLR. Three images were recorded for each knee. **Main Outcome Measures:** US images were processed using ImageJ software. Femoral cartilage thickness was assessed as the straight-line distance between the cartilage-bone interface and the synovial space-cartilage interface at the midpoints of the medial condyle, lateral condyle, and intercondylar notch. Femoral cartilage area, echo-intensity_AVG, and echo-intensity_SD were assessed by outlining the cartilage in each US image. Echo intensity was calculated as the average grayscale value across all pixels in the selected area (0 = black, 255 = white). Dependent t-tests were used to compare US outcomes between the ACLR and contralateral limbs. A one-way ANCOVA was used to evaluate the influence of cartilage area on the echo-intensity outcomes ($\alpha < 0.05$). **Results:** The ACLR limb presented with greater femoral cartilage area than the contralateral limb (96.7 ± 22.7 mm2, 85.7 ± 17.6 mm2; $t19 = 4.47$, $p < 0.001$). While thickness was greater in the ACLR limb at all measurement sites, only the medial condyle thickness was significantly greater in the ACLR limb (2.60 ± 0.61 mm, 2.36 ± 0.47 mm; $t19 = 2.78$, $p = 0.012$). Initially, we observed greater echo-intensity_SD in the ACLR limb compared to the contralateral limb (11.9 ± 1.4, 10.9 ± 1.5; $t19 = 2.65$, $p = 0.016$), without statistically significant differences in echo-intensity_AVG (67.6 ± 5.1, 65.6 ± 5.0; $t19 = 1.9$, $p = 0.068$). However, after controlling for the influence of cartilage area, the ACLR limb presented with greater echo-intensity_AVG (68.6 ± 3.6, 64.7 ± 3.6; $F = 11.14$, $p = 0.002$) and echo-intensity_SD (12.0 ± 1.4, 10.8 ± 1.4; $F = 6.6$, $p = 0.014$). **Conclusions:** Multiple outcome measures indicate increased femoral cartilage structure size in the ACLR limb, which is consistent with previous MRI literature that demonstrate greater cartilage size following ACLR and early stages of OA. As greater echo-intensity_AVG is indicative of lesser relative water content, this finding is consistent with previous theories that greater cartilage size may be due to hypertrophy of the femoral cartilage.

Chronicity of Quadriceps Function in ACL Reconstructed Patients With and Without Knee Osteoarthritis

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Context: Central and peripheral neural adaptations from muscular, spinal, and supraspinal regions have been identified following ACL injury and reconstruction (ACL-R), and are hypothesized to contribute to post-traumatic muscle dysfunction. Currently, there is limited evidence with regard to the temporal nature of neuromuscular adaptions during early and late-term durations after ACL-R, and none that include patients with post-traumatic osteoarthritis. **Objective:** To compare quadriceps neuromuscular function early (<1 year) and late (>2 years) after ACL-R, including patients who experienced post-traumatic knee osteoarthritis. **Design:** Cross-sectional. **Setting:** Laboratory. **Patients or Other Participants:** 102 participants volunteered for this study, including 72 patients after ACL-R: early (n = 34, age = 22.5 ± 6.3, height = 174.1 ± 11.0 cm, mass = 73.9 ± 16.9 kg, time from surgery = 9.0 ± 4.3 months), late (n = 30, age = 24.9 ± 5.9, height = 171.7 ± 11.8 cm, mass = 74.9 ± 16.2 kg, time from surgery = 70.5 ± 41.6 months), radiographic knee osteoarthritis (n = 8, age = 45.4 ± 7.4, height = 170.0 ± 9.7 cm, mass = 85.2 ± 24.8 kg, time from surgery = 115.9 ± 110.0 months), and 30 healthy controls (age = 22.7 ± 4.6, height = 174.8 ± 11.8 cm, mass = 75.1 ± 16.2 kg). **Interventions:** None. **Main Outcome Measures:** Normalized knee extension maximum voluntary isometric contraction (MVIC) torque (Nm/kg), quadriceps fatigue index (% decline), quadriceps central activation ratio (CAR, %), quadriceps Hoffmann reflex (H:M ratio) and quadriceps active motor threshold (AMT, 2-Tesla) were measured bilaterally. Comparisons were made using two-way analyses of variance to determine the effect of limb and group on each outcome measure. **Results:** Involved limb MVIC torque was lower among all ACL-R patients compared to healthy controls (early: 1.9 ± 0.6 Nm/kg, late: 2.2 ± 0.6 Nm/kg, osteoarthritis: 1.7 ± 0.7 Nm/kg vs. healthy: 2.8 ± 0.6 Nm/kg; $p < .001$), but did not differ between early, late, and osteoarthritic patients ($p > .05$). Fatigue index in patients early after ACL-R (14.3 ± 9.7%) was lower (less fatigable) compared to healthy controls (22.0 ± 8.0%; $p = .002$) and compared to the late group (21.7 ± 7.6%; $p = .003$). CAR was lower in patients early after ACL-R (85.5 ± 11.4%) compared to healthy controls (95.2 ± 5.6%; $p < .001$), patients late after ACL-R (90.5 ± 8.4%; $p = .015$), and patients with osteoarthritis (92.6 ± 6.8%; $p = .028$). AMT was highest (decreased corticospinal excitability) among patients early after ACL-R and those with osteoarthritis compared to healthy controls (early: 45.8 ± 7.9, late: 42.8 ± 9.1, osteoarthritis: 50.8 ± 7.6 vs. healthy: 39.0 ± 4.1%; $p < .001$). **Conclusions:** Neuromuscular impairments are present in patients early and late after ACL-R with and without knee osteoarthritis. Quadriceps strength and active motor threshold were impaired at each time point compared to healthy individuals, suggesting the role of addressing cortical function early following ACL-R. Understanding the temporal nature of neural adaptations may provide insight with regard to therapeutic management following ACL reconstruction.

Effects of Proprioception Training on Patient Outcomes for Knee Osteoarthritis: Systematic Review and Meta-Analysis

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Context: Proprioception training has been reported to be an effective treatment in patients with knee osteoarthritis (OA). However, the randomized controlled trials (RCTs) and high-methodological quality research regarding proprioception training are limited. **Objective:** To analyze the effects of proprioception training on patient outcomes (pain, stiffness, function and functional test) during short- and long-term follow-up in patients with knee OA via systematic review and meta-analysis. **Data Sources:** A computerized search was performed using PubMed, MEDLINE, CINAHL, and SPORTDiscus from 1968 to November 2015. Search terms were "proprioception or neuromuscular or balance exercise", "Western Ontario and McMaster Universities (WOMAC) or Visual Analogue Scale (VAS) or Numerical Rating Scale (NRS) or Knee Injury and Osteoarthritis Outcome Score (KOOS) or International Knee Documentation Committee (IKDC) or Tegner Activity Scale (TAS) or Short Form-36 Health Survey (SF-36) or Berg Balance Scale (BBS) or Walking Speed Time Test (WST) or Timed Get Up and Go Test (TGUG) or Chair Stand Test (CST) or 6-Minute Walk Test (6MWT)" and "OA or osteoarthritis". **Study Selection:** Studies were included if they met the following criteria: (1) Subjects with OA, (2) Subjects with proprioception training, (3) written in English, and (4) mean, standard deviation, and sample size of each group had to be reported. All sources were cross-referenced to identify additional relevant studies. **Data Extraction:** Methodological quality was assessed using the Physiotherapy Evidence Database (PEDro) scale and

appraised the levels of evidence using the Oxford Centre for Evidence-based Medicine (OCEBM) guidelines. The effect size (Cohen's D) and 95% confidence intervals (CIs) were calculated for the patient outcomes (pain, stiffness, function and functional test). **Data Synthesis:** In total, seven RCTs involving 558 patients with knee OA met the inclusion criteria. The range of selected studies PEDro scale was between 6 and 8. Levels of evidence was OCEBM level 2. Based upon the Meta-analysis results of WOMAC pain subscale (SMD: −.53, 95% CI: −.80 to −.27, $p < 0.001$), function subscale (SMD: −.49, 95% CI: −.80 to −.17, $p = 0.002$), and non-WOMAC walking speed test (SMD: −1.07, 95% CI: −2.12 to −.01, $p = 0.048$), proprioception training had significant treatment effects. However, proprioception training was not associated with significant reductions in the WOMAC stiffness subscale and non-WOMAC Timed Get Up and Go test scores. **Conclusions:** Proprioception training effectively promotes pain relief and functional improvements in the daily activities of patients with knee OA and could be included in rehabilitation programs. However, physical stiffness and mobility function did not change after proprioception training. For physical stiffness relief and mobility function improvement, modified proprioception training is recommended.

Free Communications, Oral Presentations: Lower Extremity Movement Screening and Injury Prevention

Wednesday, June 28, 2017, 5:00PM-6:15PM, Room 370; Moderator: Darin Padua, PhD, ATC

Prediction of Core and Lower Extremity Injuries Among High School Football Players

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Context: Multivariable prediction models are needed to identify high-risk athletes through pre-participation screening. To date, few studies have identified risk factors through predictive modeling in high school athletes. **Objective:** To identify pre-participation screening measures that demonstrate a substantial association with subsequent core or lower extremity (CLE) sprain or strain among high school football players. **Design:** Retrospective and prospective cohort study. **Setting:** Athletic facilities. **Patients or Other Participants:** 61 high school football players (Age: 15.4 ± 1.2 years, Height: 1.80 ± .08 m, Mass: 80.31 ± 15.07 kg,). **Interventions:** Pre-participation injury risk screening. **Main Outcome Measures:** Retrospective and prospective analyses were performed to assess associations between screening measures and injury. The retrospective injury definition was any CLE sprain or strain that resulted in sport time loss, whereas the prospective injury definition was any CLE sprain or strain during the season that required evaluation and treatment. Horizontal trunk hold (HTH) time to failure was used as an indicator of core muscle endurance. The Y-balance anterior reach (Y-AR) distance, represented as the percent of leg length, was used to assess balance and mobility. Power was assessed by a unilateral vertical jump (UVJ), using an instrumented mat. Ankle inversion strength was measured by a hand-held dynamometer. A 0-100 Sport Fitness Index (SFI) score was used to quantify persisting effects of previous injuries. Prediction models were developed from receiver operating characteristic and logistic regression analyses. **Results:** A 3-factor retrospective prediction model for time loss CLE injury included SFI (Adj OR = 4.42), HTH (Adj OR = 2.23), and Y-AR asymmetry (Adj OR = 1.40). The odds for previous CLE injury were 3.7 times greater among players who exhibited any 2 of 3 risk factors (90% CI: 1.27, 10.57). A 5-factor prospective model for CLE sprain or strain included inversion ankle strength asymmetry (Adj ORj = 5.19), Y-AR asymmetry (Adj OR = 3.59), SFI (Adj OR = 3.16), Y-AR percent leg length (Adj OR = 2.65), and UVJ asymmetry (Adj OR = 2.39). The odds for a CLE sprain or strain was 8 times greater among players who exhibited any 4 of the 5 risk factors (90% 2.77, 24.43). **Conclusions:** Pre-season screening results can be used to estimate the injury risk level of individual high school football players. Pre-season and post-season assessments are integral components of a longitudinal approach to injury risk reduction, which can facilitate individualized training that targets remediation of bilateral performance asymmetries.

Functional Movement Screen and Overuse Injuries in Collegiate Club Sport Athletes

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Context: Overuse or chronic injuries are common in the lower extremity, limit participation, and their treatment uses considerable athletic training resources. Pre-season screens are typically used to predict acute injury risk. However, it is unclear if Functional Movement Screen (FMS) scores are associated with subsequent occurrence of lower extremity overuse injuries. **Objective:** To determine if pre-season FMS composite scores were different in club sport athletes who did and did not develop an overuse injury during an academic year. We hypothesized those with an overuse injury would have lower pre-season FMS composite scores. **Design:** Cross-sectional. **Setting:** Biomechanics Laboratory. **Patients or Other Participants:** Volunteer collegiate club rugby and ultimate frisbee athletes (n = 40; 20 female [13 rugby, 7 ultimate], 20 male [12 rugby, 8 ultimate]; age = 20.7 ± 1.7 yrs; height = 172.2 ± 8.6 cm, mass = 74.9 ± 16.2 kg). **Interventions:** Participants were consented, interviewed for injury history, and screened by an experienced rater at the beginning of the academic year prior to their club sport participation. Overuse injury was defined as one without a traumatic mechanism, with a gradual onset, that lasted more than 2 weeks. Participants entered physical activity and injury occurrence weekly via online surveys for an academic year, August to May. Acute injuries with a clear mechanism, concussions, contusions, and abrasions were excluded. Participants may have reported >1 overuse injury, but were only counted once in the overuse injury group. **Main Outcome Measures:** FMS composite scores were transformed into ordinal

ranked scores, while groups were divided into overuse injury and no overuse injury. A Mann-Whitney U test was conducted to determine if those with overuse injury had lower pre-season FMS composite scores than those without ($\alpha < 0.05$). **Results:** All participants had experienced at least one previous lower extremity injury in the past 5-8 years. Average response rates were >66% over the 24-week academic period. Of the 40 participants, 15 (37.5%) reported an overuse injury (FMS composite 16.3 ± 1.9), while 25 (62.5%) did not (FMS composite 14.6 ± 2.8). Overuse injuries included tendinopathy, medial tibial stress syndrome, and knee and ankle joint pain. The Mann-Whitney U test was statistically significant (U = 116, Z = -2.0, P = 0.04, Effect Size = 0.7, Power = 0.6). **Conclusions:** Occurrence of an overuse injury in collegiate club rugby and ultimate frisbee athletes was associated with higher pre-season FMS scores. This finding does not support the hypothesis, or what has been reported in most previous literature, in which lower FMS composite scores were associated with increased acute injury risk and sometimes overuse injury risk. Higher scoring club athletes may have better movement profiles, but may also be more likely to develop overuse injuries. Injury prevention strategies may be necessary even in a high scoring group, though the efficacy of FMS with regards to overuse injuries is still unclear.

Intra- and Inter-Rater Reliability of the Selective Functional Movement Assessment (SFMA) in Healthy Subjects

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Context: The Selective Functional Movement Assessment (SFMA) is a popular evaluation tool used by trained health care professionals. This dynamic assessment attempts to identify causes for limitations or compensations throughout the body through a series of top-tier and breakout assessments. Each movement in the system is categorically graded into one of the following: 1) Functional non-painful (FN), 2) Functional painful (FP), 3) Dysfunctional non-painful (DN), or 4) Dysfunctional painful (DP). Based on findings from the entire assessment, limitations are categorized as a tissue extensibility dysfunction, joint mobility dysfunction, or stability-motor control dysfunction. Despite the SFMA coming from the same authors as the Functional Movement Screen, there are few published studies on the assessment. **Objective:** To assess the intra- and inter-rater reliability of the top-tier assessments of the SFMA in a group of healthy individuals among raters with varying levels of experience. Raters experience ranged from no formal experience (Rater C) to 2 or 4 years' experience following the SFMA course (Raters B & A respectively). **Design:** Repeated measures. **Setting:** Patient clinic. **Patients or Other Participants:** Twenty-five (17 male, 8 female) physically active participants, age: 21.2 ± 1.6 years old, weight: 74.9 ± 13.9 kg, height: 177.1 ± 10.7 cm volunteered to participate. **Interventions:** Participants were scored by 3 examiners in-person during 2 live sessions on the 10 top-tier movement patterns (1. Cervical flexion, 2. Cervical extension, 3. Cervical rotation, 4. Upper extremity pattern 1, 5. Upper extremity pattern 2, 6. Multi-segmental flexion, 7. Multi-segmental extension, 8. Multi-segmental rotation, 9 Single-leg balance, and 10. Overhead deep squat). The testing sessions were separated by a minimum of 48 hours and maximum of 7 days. The same standard instructions were read by Rater B during all testing sessions. **Main Outcome Measures:** Raters categorically scored each movement pattern using FN, FP, DN, DP. Intra- and inter-rater reliability were calculated among the raters using the Kappa coefficient and absolute agreement. **Results:** Overall, intra-rater reliability (Kappa, % agreement) was higher (0.52, 80%) than inter-rater reliability (0.45, 75%). Intra-rater reliability for all 3 raters ranged from 0.21-1.0, 64-100% agreement and was highest for Rater B, followed by C&A respectively. Multi-segmental extension produced the lowest intra-rater reliability among the raters (0.35, 72%) while the overhead deep squat produced the highest (0.84, 93%). Inter-rater reliability ranged from 0.19-0.70, 57-91% agreement. Multi-segmental extension produced the lowest reliability (0.19, 57%) while cervical flexion produced the highest (0.70, 87%). Raters A&B had the highest inter-rater reliability (0.55, 81%) followed by B&C (0.42, 75%) and A&C (0.37, 69%). **Conclusions:** Based on the interpretation of the Kappa coefficients, fair to moderate intra- and inter-rater reliability were established for the 10 movements. The highest reliability for the assessment was achieved between two experienced clinicians during the same testing session.

The Effect of a Preventative Training Program on Neuromuscular Control in Elite Adolescent Athletes During Double- and Single-Limb Functional Tasks

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Context: Functional tasks are frequently used to evaluate neuromuscular control and theoretical injury risk. Many tasks that evaluate neuromuscular control utilize a double-limb activity. Preventative training programs (PTPs) have been shown to improve neuromuscular control in double-limb activities. Many functional and athletic tasks are performed on a single limb; therefore, utilizing a single-limb activity to evaluate neuromuscular control may be warranted. **Objective:** To evaluate the effect of a PTP on neuromuscular control during a single-limb and double-limb task measured by the single-limb squat (SLS) and jump-landing task, respectively. A secondary purpose was to evaluate the association between neuromuscular control during SLS and jump-landing task. **Design:** Cohort. **Setting:** Field study. **Patients or Other Participants:** Forty-seven competitive female basketball athletes (12 ± 2 years, 165.1 ± 10.2 cm, 56.7 ± 14.1 kg) from eight teams volunteered to participate. **Interventions:** Participants were screened for neuromuscular control at the beginning (PRE) and end (POST) of a 12-week competitive season using two tasks: three trials of a jump-landing task and five repetitions of a SLS. Tasks were videotaped from the front and side and were graded by a single rater at a later date. Neuromuscular control during the jump-landing task was evaluated using the Landing Error Scoring System (LESS). The SLS was evaluated for the presence of neuromuscular control errors (knee frontal plane motion, insufficient knee flexion, and general instability were evaluated bilaterally for a maximum of 6 errors) using valid and reliable operational definitions. An athletic trainer with experience in exercise prescription and neuromuscular training designed 10-minute, team-based PTP warm-ups consisting of flexibility, strength, balance and agility exercises. PTPs were performed prior to practice (2-3x/week) for 12 weeks. **Main Outcome Measures:** The average number of errors was calculated for both tasks. Two separate repeated-measures ANOVAs were used to evaluate average LESS and SLS score, respectively, from PRE to POST. We used a correlation to evaluate the association between SLS score and LESS score with all outcome data. Significance level was set a priori at $\alpha = 0.05$. **Results:** Both LESS ($P < 0.001$, mean difference ± SD = 1.19 ± 0.28, 95% CI = [0.63, 1.76]) and SLS ($P < 0.001$, mean difference ± SD = 0.80 ± 1.42, 95% CI = [0.38, 1.23]) scores significantly improved from PRE to POST. A small but significant association existed between SLS and LESS score($R2 = 0.07$, $P = 0.007$). **Conclusions:** The PTP intervention reduced the average number of errors from PRE to POST in both tasks. While SLS and LESS were significantly positively correlated, only 7% of the variance in either the SLS or LESS can be explained by the results of other task. This indicates that a PTP that successfully improves neuromuscular control during a jump-landing task also improves neuromuscular control in a SLS; however, the jump-landing task and SLS are potentially evaluating different aspects of neuromuscular control. Further investigation of a SLS for evaluating neuromuscular control is warranted.

High Intensity Functional Movement (HIFM) Protocol Improves Movement Pattern Efficiency and Overall Work Capacity in an Offensive Lineman With an Arm Length Discrepancy

Dietrich SR, Wheeler Dietrich WN: East Stroudsburg University, East Stroudsburg, PA

Background: 25 year old male, US marine corps veteran and NCAA D2 college football player with diagnosed mechanical imbalances of the upper and lower body. Pathologies include right shoulder impingement syndrome and tendonitis of the distal head of the bicep, left knee patellar tendonitis and right leg hip flexor tendonopathy. Patient served 6 years active duty prior to participation in college football. Prior history of humeral fracture involving the growth plate, resulted in 1 ½ inch greater right arm length when compared to left. A 95lb weight gain over past 2 years was observed. Upper extremity pathologies: impingement syndrome, Labral tear, Rotator cuff strain, Erb's Palsy, chronic regional pain syndrome. Lower body pathologies: chronic regional pain syndrome, quadriceps tendonitis, proximal quadriceps strain, labral tear and bursitis. **Treatment:** A 6 week high intensity functional movement (HIFM) protocol was prescribed for this patient 1 month after spring practice ended. Four consecutive, 90min workouts were completed weekly (M-Th) followed by one day of rest and two days of active recovery. Workouts structured as follows: foam roll (10 min), stretch (10 min), dynamic warm-up (20 min); technique work (20 min), metabolic conditioning (20 min), and static stretches (10 min). Initial technique work focused on core stability, scapular muscle endurance transitioning into movement proficiency with total body exercises: Turkish get-ups, over-head squats, thrusters, single-leg squats, inverted rows and single-arm dumbbell snatch. Metabolic conditioning was anaerobic, maximal exertion bouts lasting between 8 and 20

minutes and included measureable tasks like weighted wall balls for time, 20 min AMRAP, EMOM, and TABATA style workouts. Static power band stretches, held for a :45 sec count targeting lower extremity flexibility and shoulder mobility completed each workout. **Results:** Pre and post conditioning data showed a 4 minute improvement in 100 rep wall ball assessment, FMS data shows a 6 point improvement in FMS composite scores (15/21). A 57% reduction in treatments requiring modalities (42/24) was found when comparing treatment frequency data between 2014 and 2015. Initial DPAS scores were: 39 (2013), following traditional treatment 33 (2014); and in-season s/p HIFM training 18 (2015). DPASS MCID for chronic injuries is 6. Pre intervention pain at worst was reported at 6/10, pain at best was 2/10. Post intervention pain at worst was 1/10, pain at best was 0/10. Data from a third and final sport season (2016) following traditional training is currently being collected and analyzed. **Uniqueness:** HIFM exercise helped dramatically improve the overall work capacity and movement proficiency for this patient as measured by anaerobic strength endurance task (timed wall balls) and the functional movement screen (FMS). Many service men and women experience a difficult transition back to civilian life, and participation in a team sports might ease this transition. Being prepared physically and mentally for battle does not translate well for maintaining life-long healthy lifestyles. This intervention was successful in improving this patient's physical work capacity which in previous years might have been hindered by training for hypertrophy. **Conclusions:** Athletic Trainers must be prepared to treat patients who are transitioning back to civilian life after careers in the armed forces. People exposed to extremely stressful events are at a higher risk for developing post-traumatic stress (PTS). Research on US war veterans shows those suffering with (PTS) experience a lower quality of life, poorer mental and physical health. These patients have a greater need to adopt healthy lifestyle behaviors. In this case traditional hypertrophy training provided an increased opportunity for this patient to load an inefficient movement pattern exacerbated by an arm length discrepancy and repeated sub maximal repetitions. A more functional, high intensity core to extremity approach allowed muscular adaptation through explosive single arm and leg movements which improved balance, core stability and overall work capacity.

Free Communications, Oral Presentations: Lateral Ankle Sprain Treatment: Do It Because It Works

Thursday, June 29, 2017, 7:00AM-7:45AM, Room 370; Moderator: Thomas Kaminski, PhD, ATC, FNATA

Athletic Training Services in the Treatment of Ankle Sprains Sustained During High School Athletics

Simon JE, Wikstrom EA, Grooms DR, Docherty CL, Dompier TP, Kerr ZY: Ohio University, Athens, OH; University of North Carolina at Chapel Hill, Chapel Hill, NC; Indiana University, Bloomington, IN; Datalys Center for Sports Injury Research and Prevention, Indianapolis, IN

Context: Limited information exists on the amount and type of care provided by athletic trainers (ATs) treating athletes who sustain ankle sprains in the high school setting. Ankle sprains are highly prevalent with approximately 600,000 ankle sprains per year in the United States costing approximately $2 billion. The majority of research regarding the documentation of injury has focused on the incidence rather than the management of these injuries. **Objective:** Describe AT services provided for ankle sprain injury care in high school athletics. **Design:** Descriptive epidemiological study. **Setting:** During the 2011-2012 through 2013-2014 school years, the high school National Athletic Treatment, Injury and Outcomes Network (NATION) captured injury and AT service data for 27 high school sports during pre-season, regular season, and post-season practices and competitions. Athletic training room (ATR) visits and AT services were collected from 147 high schools from 26 different states. **Patients or Other Participants:** High school student-athletes participating in 13 boys' and 14 girls' sports who sustained a diagnosed ankle sprain. ATs documented 3213 ankle sprains. **Interventions:** Athletic trainers reported injuries and athlete-exposures. **Main Outcome Measures:** The number of ATR visits and individual AT services, the mean ATR visits (per injury) and AT services (per injury) were calculated by sport, and for time loss (TL) injuries (participation restriction time of at least 24 hours) and non-time loss (NTL) injuries (participation restriction time <24 hours). **Results:** During the three-year period, 19925 ATR visits were reported, with an average of 6.20 ± 8.11 ATR visits per ankle sprain. Most ATR visits were for NTL injuries (65.1%). Football comprised the largest proportion of ankle sprains (27.3%) and ATR visits (35.0%), although football comprised the largest proportion of ankle sprains (n = 878; 27.3%). Among girls' sports, soccer had the highest number of ATR visits (n = 1649; 8.3% of all ATR visits). Overall, 71404 AT services were provided for ankle sprains. Therapeutic activities or exercise were the most common AT service (47.4%), followed by neuromuscular re-education (16.6%), strapping (14.2%), and modalities (11.5%). An average 22.2 ± 33.2 AT services were reported per ankle sprain. The average number of AT services per injury was higher among TL than NTL injuries (34.7 vs. 19.0; $p < 0.001$). **Conclusions:** The quantity of AT services vary by sport and between TL and NTL ankle sprains. Our results suggest that NTL ankle sprains accounted for approximately one third of all documented AT services. ATs provide a range of therapeutic exercises and neuromuscular re-education in the treatment of ankle sprains which is supported by research. However, ATs could consider increasing the use of manual therapy techniques which were rarely implemented but are supported in research. In addition, taping may be over utilized relative to the evidence to support its implementation post ankle sprain.

Secondary School Athletic Trainers' Documentation Strategies and Clinical Management of Acute Lateral Ankle Sprains

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Context: Acute lateral ankle injuries are amongst the most common musculoskeletal conditions in the athletic population. Early recognition and treatment of acute lateral ankle sprains (LAS) positively impact patient outcomes. It is important to understand the current management strategies used by athletic trainers for acute LAS to reflect on current practice and improve patient care. Additionally, an essential component to improve the quality and continuity of care is through accurate medical documentation. **Objective:** The aim of this study was to determine current treatment strategies for acute LAS as documented in electronic medical record (EMR). **Design:** Cross-sectional document review. **Setting:** SportsWare EMR database for three secondary schools and an online Qualtrics data entry form. **Patients or Other Participants:** Data from 107 EMRs, including initial evaluations and daily progress notes, over 9 years were included. The majority of patients were male (male = 63/107, 58.9%, female = 44/107, 41.1%). The sport with the highest reporting rate of injury was basketball (36/107, 33.6%) followed by football (22/107, 20.6%), and soccer/volleyball (both 11/107, 10.3%). **Interventions:** We collected EMRs from three area secondary schools for patients diagnosed with an acute LAS. We developed a matrix of best practice guidelines as described by the NATA position statement for the management of acute LASs using a data entry-form. One researcher examined

the documented management strategies from the EMR and determined the frequency at which athletic trainers applied best practice guidelines for the management of acute LAS. **Main Outcome Measures:** Data were recorded for diagnosis, treatment and rehabilitation, imaging, return to play considerations, and prevention strategies from the included EMRs. **Results:** Within the diagnosis section, documentation for best practice guidelines were low with 27.1% of EMRs indicating passive range of motion was assessed. A majority of EMRs (77.6%) indicated the clinician palpated key structures, and performed the anterior drawer test, respectively. A majority of EMRs (73.6%) reported the use of the inversion talar tilt test. The reported diagnosis of the patient in the EMR included grade 1-61.7%, grade 2-18.7%, and grade 3-1.9% LASs. Within the treatment section, EMRs reported that clinicians utilized common interventions at a variable frequency cryotherapy (82.2%), compression (55.1%), and elevation (46.7%). Rehabilitation strategies, outcome measures, and return to play plans were all underreported or not performed. **Conclusions:** We discovered that 1) accurate medical documentation practices are lacking in the secondary school setting and/or 2) the practices of athletic trainers in the secondary school setting may not be consistent with published practice guidelines for managing LASs. Future research needs to address if athletic trainers are accurately documenting what they are doing in clinical practice.

Lack of Treatment From a Medical Professional After an Acute Lateral Sprain

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Context: Ankle sprains remain one of the most common orthopedic injuries. Despite its high occurrence rates, and the potential for development of CAI and ankle osteoarthritis, ankle sprains remain an innocuous injury. Objective: To understand the initial management and treatment sought by patients after a lateral ankle sprain (LAS) and if there are differences in subjective function and self-reported injury in those that sought treatment versus those that did not. **Design:** Cross sectional survey **Setting:** Research laboratory **Patients or Other Participants:** 175 subjects with CAI (73 males and 102 females, age = 20.9 ± 3.4 yr., mass = 81.4 ± 24.6 kg, ht = 173.5 ± 13.2 cm). **Interventions:** Subjects were given a questionnaire to obtain information on their initial LAS. The questionnaire was given in person and subjects could ask questions at any time for clarification. All subjects also filled out the Foot and Ankle Ability Measure (FAAM) and Sport subscale (FAAM-S) **Main Outcome Measures:** The primary questions of interest were: Did the subjects seek treatment from a medical professional for their initial LAS; did the subjects perform rehabilitation; was the initial LAS immobilized; and did they use crutches. The other variables measured were score on the FAAM and FAAM-S, total number of ankle sprains, and incidences of giving way **Results:** 36% (63) of subjects sought medical treatment after their LAS. Of those 63, 54 (86%) received primary treatment for their LAS from a certified athletic trainer. All of those subjects reported doing rehabilitation and using some form of immobilization for the injury. Of those not seeking treatment (64%), all reported doing no rehabilitation, or using immobilization or crutches to treat the initial injury. When comparing those that sought medical treatment (n = 63) to those that did seek medical treatment (n = 112), there was a significant difference in FAAM (p = .03) and FAAM-S scores (p = .001). Those that did not seek medical treatment scored significantly worse on the FAAM (81.21 + 3.1% vs 89.23 + 2.8%) and FAAM-S scales (72.34 + 5.3% vs 81.26 + 3.1%), indicating significantly less subjective function. Those not seeking treatment also reported significantly more ankle sprains since the initial injury (4.7 + 2.4 vs 1.9 + .90, p = .02) and more incidences of giving way each month (3.8 + 1.9 vs 1.1 + .87, p = .04) **Conclusions:** It is not surprising those that did not seek medical treatment of their LAS had worse subjective function, more ankle sprains, and incidences of the ankle giving way. The public needs to be educated on the significance of ankle sprains and the need for medical attention for appropriate management. But we also need to continue to evaluate initial management and rehabilitation to ensure those that seek treatment receive the best care to reduce re-injury rates.

Miscellaneous Best Practices Forum: Translating Time Loss Into Wins and Losses

Thursday, June 29, 2017, 8:00AM-9:00AM, Room 370; Moderator: Matthew Hoch, PhD, ATC; Discussants: Luke Donovan, PhD, ATC; Christopher Kuenze, PhD, ATC

Free Communications, Oral Presentations: Workplace Concepts in Athletic Training Practice Settings

Thursday, June 29, 2017, 10:45AM-12:00PM, Room 370; Moderator: Tory Lindley, MA, ATC

Initial Validation of a Multilevel Model of Job Satisfaction and Career Intentions Among Collegiate Athletic Trainers

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Context: Within athletic training the constructs of job satisfaction (JS) and career intentions (CI) have been predominantly examined via uni-level assessment. The work-life interface has been directly linked to both JS and CI, and thus the research on the topic has increased over the last decade. We know that work-life conflict may cause job dissatisfaction, which in turn leads to a desire to depart the profession. Additionally, as levels of conflict rise so does dissatisfaction and thoughts of leaving one's job or profession. The work-life interface is complex and with troubling data regarding attrition these constructs should be examined via a multilevel model. Individual, organizational, and sociocultural factors have all been shown to impact JS and CI. This is a multifaceted issue and in order to create retention strategies, the reasons for career departure need to be better understood. Currently there is no known multilevel model of JS and CI within athletic training. **Objective:** Validate a multilevel model of career intentions and job satisfaction among a collegiate athletic trainer population. **Design:** Cross-sectional study **Setting:** Web-based questionnaire **Patients or Other Participants:** Athletic trainers employed in NCAA Division I, II, III or NAIA colleges or universities (n = 299, 56.5% female, 43.5% male). Average age of participants was 33.6 + 8.3 with 10.3 + 7.6 years of experience. **Interventions:** A demographic questionnaire and seven Likert scale surveys **Main Outcome Measures:** Variables included responses related to Work-Family Conflict (WFC), Work-Family Enrichment (WFE), Worktime Control (WTC), Perceived Organizational Family Support (POFS), perceived Supervisor Family Support (PSFS), Professional Identity and Values (PIVS),and Attitude towards Women (ATW) **Results:** Exploratory factor analysis confirmed three subscales in the multilevel model: 1) individual factors, 2) organizational factors, and 3) sociocultural factors. The scale was reduced from 88 items to 66 items. A Cronbach's alpha of 0.92 indicates excellent internal consistency of this scale. **Conclusions:** A multilevel model highlighting individual, organizational, and sociocultural factors is a valid and reliable measure of job satisfaction and career identity among athletic trainers employed in the collegiate setting. Future testing of this scale should include confirmatory factor analysis. This scale highlights the importance of examining the work-life interface from a multilevel perspective and to avoid attributing just individual or organizational factors to issues related to the attrition within our profession. This is a multifaceted issue and in order to create retention strategies, the reasons for career departure need to be better understood.

Athletic Trainers' Perceptions of Organizational-Professional Conflict in Athletic Training Practice Settings

Pitney WA, Mazerolle SM, Melendez S: Northern Illinois University, DeKalb, IL; University of Connecticut, Storrs, CT

Context: Organizational-professional conflict (OPC) is a strife that occurs when an organization stresses a set of values and hierarchical control that run counter to those of professionals working in the organization. The current landscape for delivery of medical care through a sport organization can result in pressure exerted against the standards of medical practice upheld by athletic trainers, thus the creation of OPC. **Objective:** Examine the perceptions of OPC, including its causes and prevention, among certified athletic trainers. **Design:** Qualitative. **Setting:** Collegiate and secondary school. **Patients or Other Participants:** 19 athletic trainers (ATs) (7 (36.8%) female; 12 (63.2%) male) with 16 ± 11 years of experience. Ten participants were from the secondary school setting, 9 from the collegiate setting. **Data Collection and Analysis:** Participants were recruited for this study following a cross sectional survey examining the level of OPC. A semi-structured interview guide was created using the data generated from the OPC survey; the guide was reviewed and approved by three experts in qualitative methods who have conducted research in organizational dynamics. An inductive content analysis was used and the findings were verified with a peer debriefing, multiple analyst triangulation, and member checks. **Results:** We found the causes of OPC: 1) questioning medical decisions and 2) poor communication by the athletic trainer. When medical decisions are not understood by other parties (eg, coaches) negative encounters can occur and, thus conflict may

result. Such conflict was perceived as a normal aspect of the AT role. In other instances, poor communication by the AT led to a lack of understanding of the subsequent actions and, thus, resulted in conflict. Four themes provide insight as to how OPC is prevented: 1) Effective communication that is professional, open, and direct; 2) Relationship building/developing rapport with organizational personnel; 3) Gaining trust and respect; and 4) Organizational support. Organizational support for medical decisions is predicated on having gained the trust and respect of others in the organization. Trust and respect result from purposefully building relationships and establishing rapport with organizational personnel. The trust and respect is the result of effectively communicating in a professional manner, as well as open and direct communication based on injury/illness evidence or policy. **Conclusions:** OPC is caused by organizational personnel questioning medical decisions and/or poor communication by AT. The findings underscore the role that interpersonal skills play in preventing or mitigating conflict with organizational personnel. Communication and education may help mediate the occurrence and impact of OPC in the traditional settings, and young professionals should be made aware of its occurrence and ways to prevent it from surfacing.

Formal Work-Life Balance Practices in College and University Athletic Training Settings

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Context: Organizational factors have limited athletic trainers in finding work-life balance (WLB). Although organizational policies to address WLB exist, little is known about an athletic trainer's awareness and willingness to use policies that could assist them. **Objective:** Expand on previous investigations regarding formal organizational WLB practices in college and university athletic training settings. **Design:** Cross-sectional. **Setting:** Web-based survey. **Patients or Other Participants:** We sent 4673 emails; 51 were undeliverable and 212 respondents were excluded for not meeting the inclusion criteria (non-academic appointment, full-time employment for at least one year). Of the 1010 respondents who began our survey, 762 completed it (17.3% response rate; age = 36 ± 10 y; male = 365 40.1%, female = 395, 43.4%; years of experience = 13 ± 10; years at current place of employment = 8 ± 8 y). **Interventions:** We developed a tool from a previous qualitative study which helped us determine that athletic trainers are often unaware of formal policies or unwilling to use them due to the work environment and that they utilize informal policies more frequently. We developed the tool and conducted a content analysis with an employer, researcher, and employee to establish content validity. **Main Outcome Measures:** Participants provided information about themselves, their orientation to the workplace, formal work-place policy availability, confidence (4-point scale, 0-3), and satisfaction (5-point scale, 1-5), and aspects of workplace culture. We analyzed the data using descriptive statistics and separate one-way analyses of variance with Scheffe post-hoc analyses to account for unequal group sizes. Significance was set at $p < 0.05$ a-priori. **Results:** Although a majority of respondents (n = 514, 67.5%) indicated they completed a formal orientation with human resources, many (n = 165, 21.7%) indicated they never received any formal orientation at their place of employment. Those without any formal orientation were significantly less confident ($p = 0.010$, mean difference = -0.25 pts) and less satisfied ($p < 0.001$, mean difference = -0.35pts) with formal policies available to them, as compared to those with formal human resource orientation. When attempting to utilize formal workplace policies, those that were most commonly utilized include healthcare insurance (n = 546, 71.7%), CEU (n = 559, 73.4%) and NATA membership (n = 570, 74.8%) reimbursement. Fewer attempts were made to use sick leave (n = 216, 28.3%), paid time off (n = 235, 30.8%), or holiday pay (n = 158, 20.7%). Only 55 (7.2%) respondents indicated they utilized maternity or parental leave, while 252 (33.1%) of them are parents. Requests to utilize formal policies were overall met with support and encouragement (n = 396, 52.0%) and respondents indicated they would feel comfortable requesting to use WLB policies again (388, 50.9%). **Conclusions:** Our findings confirmed that athletic trainers in the college and university setting are not confident that they know about formal workplace policies that might help improve WLB. Respondents indicated that when they utilize policies, the experience is positive and worth repeating; however, few respondents are utilizing many policies available to them.

Burnout in Athletic Trainers: A Systematic Review of the Literature

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Context: Burnout has been described as a psychological syndrome that includes emotional exhaustion, a decreased perception of personal accomplishment, and depersonalization. Research explaining this phenomenon in athletic trainers (ATs) has increased in recent years, but a systematic review of this literature has not been published. As burnout can lead to decreased quality of work and attrition, a review of burnout literature can help ATs understand the factors associated with burnout and how to manage it effectively. **Objective:** To review published literature to identify the causes and effects of burnout in ATs. Identify any demographic variables that increase the risk of experiencing AT burnout. **Data Sources:** EBSCO: SPORTDiscus and OneSearch were utilized, using the search terms "athletic trainer" AND "burnout". **Study Selection:** Studies selected for inclusion for further analysis were written in English and investigated prevalence, causes or effects of burnout in ATs. Articles that were brief summaries or editorials were not included in the final analysis. **Data Extraction:** The initial search yielded approximately 400 articles. Articles that did not involve athletic trainers were excluded from further inspection, which limited the search to 65 articles. Full-text review was then conducted to identify peer-reviewed articles that produced original research pertaining to prevalence, causes or effects of burnout in ATs. Three articles that were in the bibliographies of the reviewed articles but not in the initial search were also reviewed and found to meet the criteria for inclusion. Of the 68 total articles, 45 were included in the final synthesis. **Data Synthesis:** Articles were categorized into observed causes, effects, or prevalence of burnout. Articles were also categorized based on which subset of the athletic training population they were observing (i.e. AT students, certified graduate assistants, high school/collegiate staff members, academic faculty). Due to the multitude of work settings (e.g. collegiate, academic, high school, graduate assistant) that were examined as well as the qualitative nature of many of the studies, meta-analysis was not performed. **Conclusions:** The review revealed that burnout is an ongoing issue facing ATs. Burnout was observed in all AT subsets. The most prevalent causes of AT burnouts were work-life conflict (i.e. inability to balance work and life responsibilities), role strain issues (e.g. poor salaries, long hours), and difficulties with professional socialization related to the "politics and bureaucracy" associated with athletics. Effects of AT burnout included health issues (e.g. fatigue, gastrointestinal distress, weight gain) and professional issues (e.g. decreased quality of work, attrition). Additional research needs to be conducted in order to further examine preventative and coping techniques for burnout in ATs.

Factors Influencing the Decision of Athletic Trainers to Leave the Profession and Enter a Different Allied Health Profession

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Context: The ability to retain quality students within the profession has taken on added significance with the recent decision requiring professional education of athletic trainers at the graduate level. In order for athletic training (AT) to remain relevant in the new healthcare environment, it must be able to retain quality recruits with the ultimate goal of eventual practice as an athletic trainer. **Objective:** To understand important factors in an individual's decision to withdraw from the AT field and enter a different allied health profession. **Design:** Qualitative study, grounded theory methodology. **Setting:** Telephone or face-to-face interviews. **Patients or Other Participants:** 46 former AT students from athletic training programs (ATPs) within District Four (14 males, 32 females, mean = 29.59 + 6.36 years) who met the following criteria: 1) successful completion of an ATP; 2) successful completion of BOC national certification exam; 3) immediate pursuit of a degree in another occupation upon graduating from an ATP. **Data Collection and Analysis:** Data were collected and analyzed from a purposeful sample via in-depth semi-structured interviews. Trustworthiness was accomplished through peer-review, data source triangulation, member checking and peer debriefing. **Results:** When specifically asked to describe the thought process behind the decision to pursue education in another healthcare profession upon completion of the respondent's' ATP, two dominate themes emerged: 1) quality of life, and 2) improved career opportunities. Quality of life was divided into the subthemes of family and compensation. Improved career opportunities was divided into the subthemes of marketability and a fall back career. **Conclusions:** Retaining the next

generation of qualified and competent AT graduates who remain in the profession is essential if AT is to continue to mature, expand its scope of practice, and become universally recognized as a health care profession for the physically active population. While the decision to change career paths is highly individualized, some common themes emerged. Specifically, the number of hours, low pay and subsequent concerns about how family life would be affected resonated in many of the responses. Respondents were unwilling to accept the low pay after factoring in the time commitment and perceived family sacrifices if they stayed in the AT profession. Improved career opportunities gained from the flexibility associated with an additional professional degree also resonated in many of the respondents' answers. Respondents commented that having dual degrees would not only increase their knowledge base and skill set, but would make them more marketable and competitive when applying for future positions. Furthermore, increased career choices associated with a dual degree would enable respondents the freedom to change positions later in their career if hours associated with AT interfered with family obligations.

Challenges Associated With Transition to Practice of Newly Credentialed Athletic Trainers

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Context: Transition to practice can be stressful for newly credentialed athletic trainers (ATs) as they transition from student to autonomous practitioner. Understanding challenges associated with this transition could provide insight to assist employers and professional programs in developing initiatives to enhance the transition. **Objective:** Explore challenges faced by newly credentialed ATs during their transition from student to autonomous practitioner. **Design:** Phenomenological qualitative. **Setting:** Individual phone interviews. **Patients or Other Participants:** 33 ATs certified between January and September 2013 participated in this study (17 female, 16 male; 23.8 ± 2.14 years; work settings included college, high school, clinic, and other). Data saturation guided the number of participants. **Data Collection and Analysis:** Participants were interviewed via phone using an interview guide. All interviews were recorded and transcribed verbatim. Data were analyzed through phenomenological reduction, with data coded for common themes and subthemes. Trustworthiness was established via member checks, peer review, and intercoder reliability. **Results:** Five themes emerged that described the challenges as participants transitioned. 1) Initially participants felt unsure of their patient care decisions, such as treatment protocols and return to play decisions, as they had never been responsible for making decisions independently. 2) As they made decisions and received positive feedback, this in turn helped participants develop confidence. 3) Communication with coaches and parents was challenging initially, especially for those in the secondary school setting. Participants felt ill prepared as they had limited or no communication opportunities with coaches and parents during professional preparation. 4) Participants also struggled with role ambiguity, as they were confused and unsure of basic organizational and administrative expectations, including development of protocols (e.g., concussion, emergency action plans), patient referrals to physicians, how to structure hours, and other aspects of their specific employment setting. 5) Mentor inaccessibility was another challenge faced by participants. Some participants had mentors, but they were often inaccessible, while other participants, particularly in the secondary school setting and with part-time employment, felt they did not have a supervisor or mentor to which they could reach out for support and guidance. **Conclusions:** Professional programs should educate students on the challenges faced to help them understand what they might expect during the transition and that they will not be alone in these challenges. Professional programs can also ensure students are obtaining the proper skills to communicate with coaches, parents, and other stakeholders. Employers should provide clear expectations and job descriptions to alleviate some of the stress and ambiguity associated with transition to practice. Employers could also provide mentoring to newly credentialed ATs, and if mentoring is not provided, newly credentialed ATs should seek out a mentor to assist during the transition.

Exploring Socialization of Athletic Trainers in Emergent Practice Settings in Athletic Training

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Context: The National Athletic Trainer's Association (NATA) employment setting statistics indicate growing numbers of athletic trainers (ATs) are employed in practice settings of performing arts, military and physician extender. Understanding socialization of ATs in emergent settings is important to assist effective induction of ATs into the field, and to understand socialization procedures that can benefit the AT, educational programs, and emergent setting employers. **Objective:** Understand socialization experiences of ATs entering emergent practice settings. **Design:** Inductive qualitative research using a grounded theory approach. **Setting:** Performing Arts, military, physician extender settings. **Patients or Other Participants:** Six male and eleven female ATs (38 ± 11 years of age) participated in our study. Participants were employed in emergent practice settings of performing arts (n = 7), military (n = 3) and physician extender (n = 7). The average years of athletic training experience was 15 ± 10 years across all settings. Data saturation was achieved with the sample. **Data Collection and Analysis:** Seventeen telephone interviews were conducted using a semi-structured interview guide. The interview guide was created from previous socialization literature, the researchers' knowledge of socialization topic, the research agenda and the settings being studied. The interviews

were recorded (www.TapeACall.com, Epic Enterprises LLC and transcribed verbatim (http://transcribeme.com, Berkley, CA). The transcribed interviews were then analyzed with a grounded theory approach that utilized open, axial, and selective coding which allowed for generation of theories based on the data. Trustworthiness was established using researcher triangulation, member checks and peer debriefing. **Results:** Three major themes emerged: 1) anticipatory socialization, 2) organizational socialization, and 3) challenges to socialization. Anticipatory socialization related to the role their professional education and previous work experiences had on their transition into the workplace. Organizational socialization experiences included both formal and informal processes used to orient the AT into their respective roles within their employment setting. Challenges to socialization revolved around two subthemes; 1) how to utilize the AT within the organizational model at their setting and, 2) overcoming the unfamiliarity of the ATs scope of practice. **Conclusions:** Changes in employment opportunities available to ATs has created a new demand for the professional AT with ATs practicing in multiple emergent settings. Our findings indicate that ATs rely on educational, personal and previous work experiences as a means of feeling prepared to enter emergent practice settings. The induction of our AT participants included formal and informal organizational socialization strategies. Our results clarify some of the ambiguity associated with emergent practice socialization and provide a foundation for further inquiry into each individual emergent setting. Educational programs may benefit from knowing how ATs in these settings are socialized so that they can provide their students with diverse experiences and important insights as they help their students prepare for employment in emergent settings.

Transition to Practice for Graduate Assistant Athletic Trainers Providing Medical Care in the Secondary School Setting

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Context: Transition to clinical practice can be challenging for newly credentialed athletic trainers (ATs) as they are expected to immediately step into roles as autonomous clinicians. For those providing care in the secondary school, this may be compounded by the fact that many practice in isolation from other healthcare providers. As this setting becomes more popular as an employment setting, understanding the transition process is necessary. **Objective:** Explore the transition to practice of newly credentialed graduate assistant ATs providing medical care in the secondary school setting. **Design:** General inductive qualitative. **Setting:** Secondary school setting. **Patients or Other Participants:** 14 newly credentialed ATs (2 males, 12 females, age 23.0±2.0 years) who were employed in the secondary school setting through graduate assistantships, had been credentialed less than one year, and completed professional bachelors' degree programs participated in this study. **Data Collection and Analysis:** We completed 14 semi-structured telephone interviews that were all recorded and transcribed verbatim. Two researchers followed the stepwise progression of a general inductive approach to analyze the data. Trustworthiness was established through multiple analysis triangulation, peer review, and member checks. **Results:** Three main themes emerged from this data, a period of uncertainty, legitimation through role engagement, and acclimation through physician relationships. A period of uncertainty, referred to the period immediately after hire when participants were anxious and felt uncertain as they began to practice independently. Participants described feeling insecure or looking for affirmation from preceptors or supervisors when they needed to make decisions. The second theme, legitimation through role engagement, signified that as the period of uncertainty dissipated participants developed more confidence in both their skills and their knowledge and gained legitimation by engaging in their role. That is, as they practiced they began to feel more secure in their role as an athletic trainer in part because of receiving positive feedback and support from members of the secondary school community (e.g., patients, team physician). Acclimation through physician relationships highlighted the support and feedback some participants experienced as they developed a relationship with the team physician, which fostered continued growth and increased confidence. **Conclusions:** To prepare for this period of uncertainty educators/preceptors should encourage and provide chances for their students to interact with members of the healthcare team as well as communicate with parents and coaches. Employers should implement initiatives to orient newly credentialed ATs to their roles, provide clear job expectations, and assign or assist with identifying a mentor. Newly credentialed ATs should seek support from many different individuals including the team physician who can provide support, feedback, and encouragement.

Clinical Measures and Their Contribution to Dysfunction in Individuals With Patellar Tendinopathy

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Context: Patellar tendinopathy is prevalent in physically active populations and it affects their quality of living, performance of activity, and may contribute to the early cessation of their athletic careers. A number of previous studies have identified contributing factors for patellar tendinopathy however their contributions to self-reported dysfunction remain unclear. Moreover, a limited number of alignment measures have been previously studied in individuals with patellar tendinopathy and may be related to perceived dysfunction. **Objective:** To determine if strength, flexibility, and various lower extremity static alignments contributed to self-reported function and influenced the severity of patellar tendinopathy. **Design:** Cross-sectional. **Setting:** Biomechanics Research Laboratory. **Patients or Other Participants:** 30 participants with patellar tendinopathy volunteered for this study (age: 23.4 ± 3.6 years, height: 1.8 ± 0.1 m, mass: 80.0 ± 20.3 kg, BMI: 25.7 ± 4.3). Participants were included if they had local tenderness in the patellar region and score Victorian Institute of Sport Assessment of Patella (VISA-P) score less than 80. **Interventions:** Participants completed two different patient-reported outcomes including the VISA-P for symptoms of patellar tendinopathy and a 10 point, Visual Analog Scale (VAS) for pain. Body-mass normalized isometric knee extension and flexion strength, hamstring flexibility and alignment measures of rearfoot angle, navicular drop, tibial torsion, q-angle (standing and supine), genu recurvatum, pelvic tilt, and leg length differences were assessed. **Main Outcome Measures:** Pearson's correlation coefficients were completed to determine significantly correlated strength, flexibility and alignment measures with each of the patient-reported outcomes. The factors with the highest correlations were used to identify factors that contribute the most to pain and dysfunction using backward selection, linear regression models. Significance for all tests was set at $p \leq .05$. **Results:** Correlation analysis found significant moderate, relationships between the VISA-P and normalized knee extension (180.96 ± 63.94%, r = 0.47, p = 0.004) and normalized knee flexion (106.18 ± 37.24%, r = 0.44, p = 0.008). The VAS (5.18 ± 2.29) had significant small to moderate correlations with normalized knee extension (r = -0.50 p = 0.002), Normalized knee flexion (r = -0.34 p = 0.03), Sit-and-reach (28.45 ± 9.42 cm, r = -0.38 p = 0.02), Active knee extension (148.37 ± 12.98%, r = -0.38 p = .02), and Supine Q angle (12.7 ± 4.94°, r = -0.38 p = 0.02). Normalized knee extension explained 22% variability of Victorian Institute of Sport Assessment of Patella (r = .47, R2 = .22, F(1,28) = 8.04, p = 0.008). BMI and Normalized knee extension explained 43% of variability of the VAS (r = 0.66, R2 = 0.43, F(2,27) = 10.33, p < 0.01). **Conclusions:** These findings put an emphasis of bodyweight management, improving knee extensor and flexor strength, posterior flexibility in patellar tendinopathy patients. Additionally, although this research was not targeting athletes specifically, adding quantified strength and supine q-angle measurements into pre-participation physical examinations may be necessary in sports medicine clinical settings to identify athletes that may be prone to patellar tendinopathy. Targeting these deficits in individuals with PT may lead to improved outcomes when attempting to treat the dysfunction and pain associated with PT.

Relationships Among Patient Reported, Demographic and Clinical Baseline Measurements in Patellofemoral Pain Patients

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Context: It is possible that patients with chronic patellofemoral pain (PFP) may present differently on patient reported, demographic, and clinical baseline measurements, compared to those with short-term pain and symptoms. Though past studies have shown that pain duration is a predictor of unfavorable recovery from rehabilitation, few studies have investigated the relationship of PFP pain duration to baseline measures. **Objective:** To determine the relationships among self-reported pain intensity, function, and duration of symptoms (DSx), along with clinical strength/endurance and patient demographics. **Design:** Secondary analysis of existing data from a single-blinded randomized clinical trial. **Setting:** Four laboratories across North America. **Patients or Other Participants:** Data from 199 PFP patients (43 males, 92 females: age = 29.1 ± 7.1 years; mass = 69.6 ± 14.1 kg; height = 1.7 ± .15 m). **Interventions:** Data for this study consisted of baseline measures after inclusion criteria were confirmed and prior to any rehabilitation exercises. **Main Outcome Measures:** Patient self-report variables included sex, age (years), DSx (months), and weekly participation in exercise/sport (hours). Height (cm) and weight (kg) was measured and BMI was calculated as mass / height2. Pain intensity was rated using a Visual

Analog Scale (cm), and functional ability using the Anterior Knee Pain Scale. Isometric peak hip strength (abduction, extension, internal rotation, external rotation) was assessed using a hand-held dynamometer with non-elastic straps, and normalized to body weight (N/Kg). Core endurance was assessed by a timed-hold of the front-plank (anterior), side-bridge (lateral), and horizontal extension (posterior) tests (sec.) Since DSx was not normally distributed, a Spearman's rank-order test was used to determine the relationship between DSx and the aforementioned variables ($p \leq .05$). Between-gender differences were examined using a Mann-Whitney U test ($p \leq .05$) **Results:** No relationship was found between gender and DSx ($U = 4243$, $Z = -.382$, $p = .702$). There were weak, yet significant positive correlations between DSx and weight with the longer DSx related to increased weight ($rs = .138$, $p = .05$), and BMI ($rs = .162$, $p = .023$). There were also weak, yet significant negative correlations between DSx and hip abduction ($rs = -.138$, $p = .05$), external rotation ($rs = -.169$, $p = .017$), and internal rotation ($rs = -.145$, $p = .042$) strength, with longer DSx related to weaker hip muscles. **Conclusions:** PFP patients experiencing pain for a longer period of time are heavier, have a larger BMI, and have less hip abduction and rotation strength. These factors may have contributed to, or resulted from having knee pain for a long period of time. This study provides additional evidence to recent research indicating that baseline measures play a role in predicting patient treatment outcome. Strategies to improve early detection and intervention are needed to improve treatment outcomes and reduce the long-term consequences of chronic PFP.

Lower Extremity Strength, Kinematics, and Activation During a Drop Vertical Jump in Individuals With and Without Patellofemoral Pain

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Context: Patellofemoral pain (PFP) is one of the most prevalent knee pathologies observed in the active population. Those suffering from PFP typically have pain completing everyday tasks such as sitting, running, stair ascent/descent, squatting, and jumping. Current research has suggested individuals with PFP have altered neuromuscular control of the lower extremity, which leads to pain. However, very few studies have examined the differences in lower extremity biomechanics between a PFP pathological and healthy population during jumping tasks. **Objective:** To determine how lower extremity range of motion (ROM), strength, surface electromyography (EMG), kinematics and kinetics, and self-reported pain-function differ between females suffering from PFP and healthy females during a drop vertical jump (DVJ). **Design:** Cross-sectional. **Setting:** Laboratory. **Patients or Other Participants:** 15 healthy (67.75 ± 9.55 kg, 169.29 ± 5.38 cm, 20.53 ± 1.68 yrs) and 15 PFP pathological (65.67 ± 13.75 kg, 166.42 ± 6.01 cm, 22.33 ± 3.49 yrs) females volunteered for participation in this study. **Interventions:** Three trials of a DVJ from a 30-cm high box set behind a forceplate. **Main Outcome Measures:** Lower extremity EMG, kinematics and kinetics of the hip and knee, and subjective pain and function were assessed using ANOVAs. Patient reported function measures included the Anterior Knee Pain Scale (AKPS), the Activities of Daily Living Scale (ADLS), and the Visual Analog Scale (VAS for pain. **Results:** A statistically significant difference was identified in subjective function AKPS (Healthy: 100 ± 0, PFP: 74.57 ± 7.89, $p < 0.001$) and ADLS (Healthy: 99.8 ± 0.77, PFP: 77.67 ± 9.66, $p < 0.001$) and in both current pain (Healthy: 0 ± 0, PFP 1.62 ± 1.78, $P = 0.001$) and pain during the DVJ: (Healthy: 0 ± 0, PFP: 2.29 ± 2.05, $p < 0.001$). PFP patients were significantly weaker than the healthy controls in both hip abduction and hip external rotation and had a significant decrease in hamstring and IT band flexibility. A statistically significant difference in muscle activity was found in the VMO (Healthy: 120.84 ± 80.73, PFP: 235.84 ± 152.29, $p < 0.05$) with a large effect size ($d = 0.94$, 95% CI (0.19, 1.7). A significant difference was seen in frontal plane kinematics, as those in the PFP group had greater excursion of hip adduction ($d = 0.78$, 95% CI (0.04, 1.52) during the DVJ (Healthy: $3.95 \pm 4.76^{\circ}$, PFP: $9.90 \pm 9.65^{\circ}$, $p = 0.041$). A relationship was identified between subjective and objective function as VAS had a moderate relationship with knee rotation excursion ($r = 0.608$, $p = 0.016$). Knee rotation excursion also had a moderate relationship with hip external rotation strength ($r = -0.541$, $p = 0.037$) in the PFP group. **Conclusions:** The findings of this study identified a relationship between hip and knee ROM and strength, EMG, and kinematics. The weakness and tightness of muscles in the lower extremity of those with PFP may alter lower extremity biomechanics during functional tasks. These results suggest that weaker hip abductors in individuals with PFP may affect pelvic control leading to increased movements at the knee, potentially resulting in anterior knee pain.

Comparison of Lumbopelvic Hip Muscle Activity Between Individuals With and Without Patellofemoral Pain

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Context: Patellofemoral pain (PFP) is one of the most common knee conditions in the physically active population. Its etiology remains unknown; however, there may be a contribution from proximal musculature in the lumbopelvic hip complex, including: transverse abdominis (TrA), gluteus maximus (GMax), and gluteus medius (GMed). Although strength and muscle activation are often assessed, ultrasound imaging can also be used to evaluate the function of these muscles between healthy and PFP patients. **Objective:** To compare muscle thickness changes of the TrA, GMax, and GMed using ultrasound imaging between participants with and without patellofemoral pain in multiple unloaded and loaded positions. **Design:** Descriptive laboratory study. **Setting:** Laboratory. **Patients or Other Participants:** 24 total participants (12 PFP: Age = 24.0 ± 5.5 years, Height = 167.2 ± 7.6 cm, Mass = 71.9 ± 18.9 kg; 12 healthy: Age = 20.3 ± 1.7 years, Height = 174.8 ± 11.6 cm, Mass = 72.5 ± 14.4 kg) volunteered for the study. **Interventions:** Ultrasound imaging with a wireless linear transducer was used to visualize muscle thickness of the abdominal wall muscles (TrA) and gluteals (GMax, GMed). **Main Outcome Measures:** Static ultrasound images were captured in resting and contracted states with participants placed in multiple positions (tabletop, bipedal standing, single leg stance, and single leg squat). The abdominal draw-in maneuver was used as the contraction for TrA in tabletop and standing, while side-lying hip abduction was used for gluteal contraction in tabletop and a gluteal squeeze as contraction during standing. Muscle thickness during the single leg stance and single leg squat was normalized to a bipedal quiet standing thickness to identify percent activation beyond quiet standing. 95% confidence intervals (CI) were also calculated for each mean difference. Cohen's d effect sizes were used to represent the magnitude of difference between groups. **Results:** Compared to the healthy individuals, the participants with PFP had a 27% (0.27; CI: 0.25, 0.30) increase in activation of the TrA during standing (P = .04, d = .87 [CI: 0.03, 1.71]) and a 10% (0.10; CI: 0.07, 0.12) decrease in GMax activation (P = .008, d = -1.37 [CI: -2.26, -0.48]) in the same position. During the single leg squat, healthy participants had a 21% (0.21; CI: 0.17, 0.24) increase in GMed activity (P = .003, d = -1.47 [CI: -2.37, -0.57]). There were no other significant differences between groups found in any of the muscles or positions. **Conclusions:** Individuals with PFP had a large difference in lumbopelvic hip muscle activation compared to the healthy controls while standing and performing a single leg squat, as measured via ultrasound imaging. The increase in TrA activity found in those with PFP may indicate a protective mechanism while standing in a loaded position due to dysfunction distally at the knee. Muscle imbalances in the PFP group may also be responsible for the altered gluteal activation during standing and during the single leg squat.

Immediate Effects of Transcranial Alternating Current Stimulation on Quadriceps Corticospinal Excitability and Voluntary Activation

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Context: Quadriceps weakness persists for months to years following knee injury, and likely results in increased disability. Persistent quadriceps weakness results from decreased voluntary activation, which may be due to underlying neural alterations in corticospinal excitability. Simultaneously targeting corticospinal excitability in addition to traditional rehabilitation may be advantageous for restoring quadriceps voluntary activation and strength. Transcranial alternating current stimulation (tACS) been demonstrated to increase corticospinal excitability in a variety of populations, however tACS has not been utilized to target quadriceps corticospinal excitability. **Objective:** To examine if tACS can acutely alter quadriceps corticospinal excitability and voluntary activation in healthy individuals. **Design:** Crossover. **Setting:** Research laboratory. **Patients or Other Participants:** Thirty-four healthy participants with no history of lower extremity surgery or injury in the past 6 months (76% female, age = 20.35 ± 1.76, height (cm) = 165.85 ± 9.51, weight (kg) = 66.76 ± 11.76). **Interventions:** Participants attended two testing sessions one week apart; the order of the intervention and control sessions was counterbalanced. During the control session participants completed isometric quadriceps contractions at 5% maximum voluntary isometric contraction every 30 seconds for 10 minutes. During the intervention session tACS was administered over the primary motor cortex using the Fisher Wallace Stimulator FW-100 while the participants completed the same isometric quadriceps contractions as the control session. **Main Outcome Measures:** Corticospinal excitability was evaluated using single-pulsed transcranial magnetic stimulation (TMS) and quantified via active motor threshold (AMT). Quadriceps voluntary activation was quantified via the central activation ratio (CAR). Each measure was taken prior to and immediately following the intervention. We calculated percent change scores from pre-intervention to post-intervention for both AMT and CAR. Dependent samples t-tests were used to determine differences in percent change in AMT and CAR between the two sessions. Secondarily, we used a Pearson product moment correlation to evaluate the association between AMT percent change scores for the two sessions. **Results:** There were no significant differences in the percent change scores between the intervention and control conditions for AMT (AMTintervention = -.733 ± 4.89%, AMTcontrol = -2.17 ± 8.67%, t33 = .813, P = .422) and CAR (CARintervention = 2.66 ± 6.14%, CARcontrol = 3.31 ± 7.71%, t33 = -.449, P = .656). There was also no significant association between the percent change in AMT during the intervention session and the percent change in AMT during the control session (r = -0.003; P = 0.987). **Conclusions:** tACS in conjunction with submaximal isometric contractions did not elicit acute changes in quadriceps AMT and CAR as compared to isometric contractions alone in healthy individuals. As changes in AMT following the intervention did not associate with changes in AMT following the control, the responses to tACS may be individualized. Determining which individuals may respond favorably to tACS may allow clinicians to target the neural origins of decreased muscle function following injury, thus allowing for improved rehabilitation outcomes.

Brain Functional Connectivity of Knee Extension Exercise Differs During External and Internal Foci of Attention

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Context: Performing a motor task with an external relative to an internal focus of attention is documented to have learning benefits. Our recent work suggests that the occipital pole/gray matter visual cortex is preferentially active during external relative to internal focus during a knee extension task. However, it is unknown if functional connectivity of this area to the rest of the brain differs with focus of attention. **Objective:** To determine brain functional connectivity differences between knee extension exercises performed with external and internal foci of attention. **Design:** Cross-sectional. **Setting:** Laboratory **Patients or Other Participants:** Healthy, recreationally active participants (2 males, age = 22 ± 0.7 yrs, height = 177.4 ± 7.7 cm, mass = 63.3 ± 0.4 kg; 4 females, age = 31 ± 17 yrs, height = 165.0 ± 5.3 cm, mass = 60.7 ± 13.0 kg) were recruited from local universities. **Interventions:** T1 brain structural imaging was performed for registration of the functional data. Participants completed external and internal focus of attention unilateral left 45° knee extension/flexion movements at a rate of 1.2 Hz laying supine in a MRI scanner for 4 blocks of 30 seconds interspersed with 30 second rest blocks. During the internal condition participants were instructed to "squeeze their quadriceps". During the external condition participants were instructed to "focus on a target" positioned 3 inches above their tibia. For each condition, 3T fMRI BOLD data representing 90 whole-brain volumes were acquired. **Main Outcome Measures:** Functional connectivity of the right occipital pole

as a seed region was examined using a psychophysiological interaction analysis for each condition. The two conditions were then contrasted using a mixed-effects general linear model with an a priori cluster threshold of $p < .05$. **Results:** During the internal relative to the external condition, the right occipital pole had significantly greater functional connectivity between the left superior parietal lobule 7A (cluster size = 814 voxels, Zmin-max = 2.3-3.7, Zmean = 2.6, $P \leq .001$) and right visual cortex V4, V3, and V2 (cluster size = 622 voxels, Zmin-max = 2.3-3.2, Zmean = 2.5, $P = .008$). There were no greater regions of functional connectivity of the external relative to internal conditions. **Conclusions:** Results indicate that the instructional strategy used to guide a rehabilitation exercise results in differing means by which the brain functions to execute the movement. Specifically, it suggests that use of an internal focus of attention results in greater information exchange between the occipital pole/visual cortex and areas that integrate visual and somatosensory information (superior parietal lobule 7A) and integrate various signals involved in body representation (regions inclusive of the extrastriate body area). We suspect that this increased functional connectivity could be a contributing factor to the typically reported poorer performances associated with internal focus. Future work should continue to investigate exercise instructional strategies with the goals of increasing learning, retention, and transference of skills.

Altered Cortical Activation Patterns Following Anterior Cruciate Ligament Reconstruction During Joint Loading

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Context: Growing evidence suggests that an ACL rupture may alter neural processing between damaged mechanoreceptors within the ACL and central nervous system. Neuromechanical coupling between the reconstructed ACL and somatosensory cortex is critical to reestablish proprioceptive acuity and neuromuscular control for joint stability during loading. However, limited electroencephalography (EEG) data exists on ACL reconstructed (ACLR) patients, who may have different neural processing strategies during ligamentous loading, compared to healthy controls. **Objective:** To determine the relationship between cortical activity and joint loading between ACLR patients and healthy controls during knee loading. **Design:** Case-control study. **Setting:** Neuromechanics laboratory. **Patients or Other Participants:** Seventeen ACLR patients (22.3 ± 3.8 yrs, 67.8 ± 18.7 kg, 164.5 ± 10.4 cm) with a unilateral ACLR and 17 healthy Controls (26.9 ± 5.6 yrs, 62.7 ± 12.0 kg, 166.3 ± 7.7 cm) with no history of knee injury volunteered. Controls matched on gender and reconstructed limbs of the ACLR patients. **Interventions:** Contralateral somatosensory electrocortical activation (CP3, CP4) in alpha-2 frequency band (10-12Hz) was quantified using EEG during an anterior ligamentous loading (3sec) on both limbs using a knee arthrometer. Constant force (45N/sec) was applied in a position of 25-35 degrees of knee flexion and a digital trigger was used to synchronize EEG signals with joint laxity data. **Outcome Measures:** Cortical activation was calculated using Event-related desynchronization (ERD: % decreased power relative to a non-active baseline; ERD1, ERD2, ERD3) during each second of the anterior loading, while the corresponding laxity was calculated for displacement (mm; LAX1, LAX2, LAX3). Pearson's correlation coefficients were used to examine relationships between dependent variables. **Results:** ERD2 activity in the injured limbs of the ACLR group showed positive relationships with LAX1 ($r = .530$, $p = .029$) and LAX2 ($r = .506$, $p = .038$), while a negative relationship was observed in the non-injured limbs between ERD2 and LAX2 ($r = -0.565$, $p = .028$). Healthy controls showed a positive relationship between ERD3 and LAX1 ($r = .515$, $p = .041$) in the injury matched limb. Additionally, uninjured matched limbs of the control group showed positive correlations between cortical activation and laxity, but were not significant ($p > .05$). **Conclusions:** The ACLR patients had different somatosensory cortical activation patterns compared to healthy controls. This supports hypotheses suggesting that neuromechanical coupling is altered between the brain and ACL, even after reconstructive surgery. Healthy controls revealed higher cortical activation with respect to greater joint laxity during ligamentous loading. However, the ACLR group revealed that higher mid-cortical activity in the reconstructed knee was correlated with greater early- and mid-joint laxity, whereas lower mid-cortical activation was correlated with greater early-joint laxity in the uninjured limb. ACL injury and surgery changes neural processing in the brain's somatosensory cortex, which is responsible for perceiving proprioceptive inputs, from both the injured and healthy limbs. Future studies may explore how these neural adaptations influence patient outcomes and the neuromuscular control necessary for maintaining functional joint stability.

Brain Motor Network Plasticity Associated with Proprioception after Anterior Cruciate Ligament Reconstruction

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Context: Anterior cruciate ligament (ACL) injury and reconstruction cause neuroplastic changes due to the lost afferent input from the ligament and developed motor compensations. These neural changes may be contributing to the proprioception deficits that influence motor control, however the neural mechanism for altered proprioception after injury is unknown. **Objective:** To investigate brain motor network activation with functional magnetic resonance imaging (fMRI), during an active knee joint positioning task in those with ACL reconstruction (ACLR) and matched controls. **Design:** Cohort study. **Setting:** Neuroimaging center. **Patients or Other Participants:** Fifteen ACLR (21.71 ± 2.68 years, 1.72 ± 0.10 m, 70.43 ± 15.83 kg, Tegner activity level 7.20 ± 1.26.0, 38.13 ± 27.16 months post-surgery) and 15 healthy controls (23.15 ± 3.48 years, 1.74 ± 0.09 m, 69.77 ± 14.27 kg, Tegner activity level 6.76 ± 1.48) matched to the ACLR participants on height, mass, extremity dominance, and physical activity level completed the study. Four of the matched pairs had to be dropped from the analysis due to excessive head motion artifact. Eleven pairs (n = 22) were included in the final analysis. **Interventions:** fMRI was collected during a unilateral knee motor task consisting of repeated cycles of extension and flexion to a targeted knee angle of 20° while laying supine in the MRI scanner. Prior to scanning, the participants received training with feedback on achieving the target angle. Due to limitations of the fMRI environment we were unable to capture joint position error during the task, and could only capture the brain activation pattern to engage in the active knee positioning task. **Main Outcome Measures:** Percent signal change of specific brain motor regions were extracted for the contrast of knee movement to target and rest, then compared between ACLR and matched controls with a general linear model second-level fixed-effects analysis a priori threshold at $p < .05$ cluster corrected. **Results:** Those with ACLR had decreased activation of the contralateral primary motor cortex (cluster data: voxels: 2190; $p < .0001$; z-max: 10.80; MNI coordinate peak voxel: 44, -22,58; %signal difference: 0.89 ± 0.76), pre-motor cortex (cluster data: voxels: 451; $p < .0001$; z-max: 7.79; MNI coordinate peak voxel: 66,6,20; % signal difference: 0.66 ± 0.64) and primary sensory cortex (cluster data: voxels: 2679; $p < .0001$; z-max: 11.0; MNI coordinate peak voxel: 6,-52,74; %signal difference: 0.55 ± 0.60), relative to matched controls to complete the active knee joint positioning task. **Conclusions:** Neuroplasticity following ACLR may be driving the depressed proprioceptive active joint positioning ability after the injury. This work indicates after injury and reconstruction the knee motor network activates to a lesser degree to engage in a joint angle targeted movement. This may partially explain the poorer proprioceptive performance typical of those with ACLR.

Relationship Between Ankle Dorsiflexion Range of Motion and Dynamic Postural Control

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Context: Increased joint stiffness at the talocrural joint and poor postural control performance measured by the Star Excursion Balance Test (SEBT) has shown an increased risk of lower extremity injury. The relationship between chronic ankle instability and dynamic postural control has been extensively researched, however the influence of active dorsiflexion on postural control in healthy, recreationally active, college aged students has not been thoroughly examined. **Objective:** The purpose of this study was to determine the relationship between ankle dorsiflexion range of motion (DFROM) and dynamic postural control. **Design:** Cross-sectional. **Setting:** Athletic training laboratory. **Patients or Other Participants:** 37 healthy, recreationally active individuals (males = 8; females = 29; age: 21.24 2.35 years; height: 168.39 9.39 cm; mass: 70.17 12.33 kg) who did not have a history of injury in the past three months volunteered to participate in the study. **Interventions:** During one testing session, ankle dorsiflexion was measured bilaterally using the weight bearing lunge test (WBLT). The measurement was taken with a digital inclinometer placed on the anterior tibia just inferior to the tibial tuberosity. Dynamic postural control was measured using maximum reach distance, measured in centimeters and normalized by leg length, during a SEBT in the anterior, posteromedial, and posterolateral directions. **Main Outcome Measures:** DFROM was grouped into two categories for both left and right leg: Restricted (DFROM $\geq$ 14 and $\leq$ 23 degrees, left n = 24, right n = 18), or Average (DFROM > 23 degrees, left n = 13, right n = 19). T-tests were used to determine differences between the Restricted and Average groups. **Results:** The left leg anterior SEBT score was significantly higher for the Average group (mean = 86.69 5.79) compared to the Restricted group (mean = 80.67 8.92); t(35) = -2.19, p = .03. The left leg composite score was also higher for the Average group, but was not statistically significant. Anterior reach in the right leg was significantly higher for the Average group (mean = 87.52 7.54) than the Restricted (mean = 78.80 6.07); t(35) = -3.85, p < .000. Right leg composite score for Average (mean = 93.47 7.30) was significantly higher than the Restricted group (mean = 87.78 5.87); t(35) = -2.605, p = .013. **Conclusions:** Decreases in DFROM were associated with decreased dynamic postural control. Decreases in dynamic postural control and increased joint stiffness at the ankle have been shown to be predictors of injury. Increasing DFROM may prevent injury from occurring and maintain dynamic postural control.

The Existence of Differences in Static and Dynamic Postural Construct Between Korean Male and Female

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Context: As similar to previous studies in United States, Korean females have greater static lower extremity alignments (LEAs) including pelvic tilt, hip anteversion, Q-angle, and tibiofemoral angle. It has been reported as ACL injury risk factors since these static LEAs could cause specific movements associated with ACL injury mechanism. Unlike United States, however, there was no gender difference of ACL injury incidence in Korean. **Objective:** To identify whether characteristics of static LEAs are reflected in dynamic LEAs in Korean. **Design:** Case control study. **Setting:** Research laboratory. **Patients or Other Participants:** A total of 100 participants (50 male: age = 22.4 ± 3.5 years, height = 175.8 ± 6.6 cm, weight = 72.7 ± 9.5 kg; 50 female: age = 22.1 ± 2.6 years, height = 163.5 ± 5.0 cm, weight = 56.4 ± 5.2 kg) were recruited for this study. **Interventions:** Gender were independent variables of this study. 8 static LEA measurements were measured by a single examiner who has established reliability (ICC > .7) before data collection. All participants were instructed to perform vertical jump after landing from the 30cm height box. Eight camera three-dimensional motion capture system (200Hz) were used to collect kinematic data during landing phase. **Main Outcome Measures:** The list of LEA measures is as follows: Pelvic tilt, hip anteversion, Q-angle, tibiofemoral angle, standing rearfoot angle, tibial varum, tibial torsion and navicular drop. Peak angles of lower extremity in frontal and transverse planes during landing phase were analyzed. An independent t-test were performed

to determine gender differences on dynamic LEAs. Stepwise regression analyses were conducted to identify association among static LEAs and dynamic LEAs in both male and female groups. **Results:** While Korean females showed significant increased peak hip adduction angle (female: -2.9 ± 4.0°, male: -6.8 ± 4.6°) and knee abduction angle (female: 9.7 ± 8.8°, male: 3.1 ± 6.9°) during drop jump, Korean males displayed significant greater peak knee internal rotation angle (female: 18.8 ± 9.4°, male: 23.9 ± 9.9°). In addition, there were no relationships between static and dynamic LEAs. **Conclusions:** Korean females displayed greater peak hip adduction and knee abduction angle which can increase tension to ACL. Interestingly, Korean males showed greater peak knee internal rotation angle which can also increase tension to ACL as compared to Korean females. However, static LEAs were not reflected to dynamic LEAs in both genders. Other contributing factors that can alter dynamic LEAs may exist in Koreans. Therefore, further study is necessary to investigate other contributing factors such as muscle activation pattern that can compensate abnormal or altered lower extremity movements.

Sensory Contributions to Balance in Student-Athletes With and Without a History of Chronic Lower Extremity Injury

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Context: Sensorimotor deficits have been noted in individuals with chronic lower extremity injuries. Researchers have indicated that chronic ankle sprains may cause individuals to use vision more than other sensory systems (somatosensory, vestibular) to maintain balance. The reweighting of the sensory systems may similarly occur in athletes with chronic lower extremity injuries, which could have implications for designing rehabilitation protocols. **Objective:** Our purpose was to examine the contributions of the sensory systems to double-limb balance in participants with and without a history of chronic lower extremity injuries. **Design:** Case-control. **Setting:** Research Laboratory. **Patients or Other Participants:** Student-athletes with (18.08 ± 0.49 yr, 173.08 ± 8.01 cm, 71.79 ± 10.88 kg; 10 females, 3 males; N = 13) and without (18.46 ± 0.66 yr, 172.07 ± 6.46 cm, 66.40 ± 11.12 kg; 10 females, 3 males; N = 13) a history of chronic lower extremity conditions (plantar fasciitis, anterior compartment syndrome, Achilles tendinitis, patella bursitis, medial tibial stress syndrome, IT band bursitis, posterior tibial tendinitis, medial tibial stress fracture). **Interventions:** Participants performed double-limb balance tests while standing atop a force plate on a NeuroCom System. Participants remained as motionless as possible for 20 seconds for each of the 6 conditions on the Sensory Organization Test. These conditions manipulate the surface (stable, unstable), surrounding (movement, no movement), and vision (eyes-opened, eyes-closed) to make balance more or less challenging. The output from these conditions are used to compute 6 equilibrium sway scores and the degree to which the 3 sensory systems (somatosensory, vision, vestibular) contribute to balance. Each condition was assessed once. One-tailed independent t-tests examined differences between participants with chronic conditions (CC) and those without (No CC) these conditions (alpha=0.05). Cohen's effect size d values also were computed. **Main Outcome Measures:** Equilibrium scores closer to 100 indicated greater stability and sensory ratios closer to 1 indicated an increased use of a sensory system (somatosensory, vision, vestibular). **Results:** The CC group had significantly greater stability during balance on a stable surface with their eyes opened (CC = 95.15 ± 1.91, No CC = 93.46 ± 2.82; t(24) = 1.79, P = 0.04; d = 0.70) No other significant differences were found for the other 5 equilibrium scores or 3 sensory ratios (P > 0.05). However, interesting effect size values were noted in the sensory ratios that suggest the CC group used less somatosensory input (CC = 0.97 ± 0.03, No CC = 0.99 ± 0.03; d = 0.56), but more visual input (CC = 0.81 ± 0.17, No CC = 0.77 ± 0.20; d = 0.20) than the No CC group. Groups used similar vestibular input (CC = 0.61 ± 0.17, No CC = 0.60 ± 0.11; d = 0.09). **Conclusions:** Participants with CC had greater stability while balancing on a stable surface with their eyes opened. When examining the sensory system comparisons, low-to-moderate effect size values (that should be statistically detectable) were found, suggesting that the CC group used more vision and less somatosensation. Chronic conditions may cause a reweighting of the sensory systems, but future investigations need conducted to confirm these preliminary findings.

Visuomotor Training for Injury Risk Reduction Among College Football Players

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Context: Visuomotor reaction time (VMRT) is an important component of neuromuscular responsiveness and injury risk. Poor VMRT can lead to increased risk of not only musculoskeletal injury but also concussion. There is a paucity of research concerning whether VMRT can be improved, and if so, whether it may lead to reduced injury risk. **Objective:** To assess the possible benefits of pre-season VMRT training on injury risk among collegiate football players. **Design:** Repeated-measures cohort. **Setting:** Sports Medicine Clinic. **Patients or Other Participants:** 13 NCAA Division-I football players (20.1 ± 1.4 years; 105.84 ± 19.57 kg; 188.16 ± 4.69 cm) who completed VMRT training were compared to 36 controls (19.9 ± 1.1 years, 101.33 ± 21.18 kg, 184.14 ± 5.62 cm). **Interventions:** Prior to preseason training, all participants underwent baseline VMRT assessment using the Dynavision® D2 system. Three testing modes were used: Proactive (illuminated buttons remain lit and participant strikes them as quickly as possible), Reactive (buttons only remain illuminated for 750ms and participant simultaneously reads scrolling text on LCD screen), and Reactive+BOSU (similar test as 'Reactive' mode but participant also maintains bilateral postural balance while standing on BOSU device). Participants in the VMRT training group then completed 9 sessions of graduated training over a 3-week period, followed by post-training testing. Core and lower extremity (Core/LE) injury data was collected prospectively throughout the following pre-season and 12-game season. **Main Outcome Measures:** For the Proactive mode, average response time overall and for each of 5 concentric rings was calculated. For both reactive tests (with and without BOSU), number of hits overall and for each of the 5 concentric rings was calculated, with a higher number of hits indicating better VMRT performance. Cross-tabulation analysis was performed to assess associations between risk classification (starter vs. nonstarter; training vs. no training) and injury occurrence. Paired t-tests were used to analyze differences between pre- and post-training performance. **Results:** A total of 18 injuries were sustained among 17 of the 49 participants. No difference in injury incidence was found between starters and nonstarters ($\chi 2 = 0.63$; $p = .310$; OR = 0.62, 90% CI: 0.23-1.68). Untrained players were 3.93 times more likely to sustain a Core/LE injury than those who completed VMRT training ($\chi 2 = 2.91$; $p = .083$; OR = 3.93, 90% CI: 0.99-15.64). Comparison of outer-to-inner ring performance ratio was significantly improved following training (Pre-training = 1.63 ± 0.17; Post-training = 1.44 ± 0.13; $t = 3.97$; $p = .002$), indicating a higher percentage of peripheral buttons hit during reactive mode testing after training. Reactive+BOSU performance improved with training, but its association with injury was weaker than that obtained during the basic reactive test. **Conclusions:** Reactive VRMT training improved performance and appeared to lower injury incidence, which may be explained by improved peripheral perception of environmental stimuli beyond a 45 degree viewing-angle. More research is needed to refine VMRT training methods for integration of central-peripheral visual input.

No Changes in Y-Balance Test Performance Following a Competitive Field Hockey Season

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Context: The Y-Balance Test (YBT) is a dynamic balance assessment which can be included as part of a preseason musculoskeletal screen to help determine injury risk. While the YBT has demonstrated excellent inter-rater and intra-rater reliability, little is known about changes in YBT performance that may naturally occur following training such as participation in a competitive sport season. Because musculoskeletal injury risk screens are often performed annually at the beginning of a competitive sport season, it is important to understand the effects of time and physical activity on performance. **Objective:** To determine the effects of a competitive athletic season on YBT performance in healthy field hockey players. **Design:** Pretest-posttest. **Setting:** Laboratory. **Patients or Other Participants:** Sixteen NCAA Division I women's field hockey players (age = 19.38 ± 1.31 years; height = 154.78 ± 138.07 cm; mass = 58.84 ± 16.56 kg) volunteered to participate. To be included, subjects had to be free from injury throughout the entire study period and participate in all athletic activities. **Interventions:** All subjects completed data collection sessions prior to commencement of the athletic season (preseason) and following cessation of the athletic season (postseason). Between data collection sessions, all participants participated in the fall competitive field hockey season, which was approximately 3 months in duration. During each data collection session, all participants completed the anterior, posteromedial and posterolateral directions of the YBT barefoot on each limb. For all assessments, participants performed 4 practice trails followed by 3 data collection trials in each direction. Reach

distances for each direction were averaged and normalized to leg length (%). **Main Outcome Measures:** The independent variable was time (preseason, postseason) and the dependent variables were YBT reach distances (anterior, posteromedial, posterolateral). Differences between preseason and postseason reach distances were examined for each reach direction using paired t-tests and Hedge's g effect sizes (ES). Alpha was set at $p \leq 0.05$ for all analyses. **Results:** There were no significant differences between the right and left limbs for any time or reach directions. Therefore, right and left measurements were pooled for analysis. There were no significant differences between preseason and postseason reach distances in the anterior (preseason: 63.14 ± 3.81%, postseason: 62.86 ± 4.34%; t(15) = 0.47, p = 0.64, ES = 0.07), posteromedial (preseason: 102.00 ± 8.16%, postseason: 102.96 ± 8.11%; t(15) = -0.52, p = 0.61, ES = -0.12) or posterolateral (preseason: 99.23 ± 8.29%, postseason: 100.89 ± 8.85%; t(15) = -1.14, p = 0.27, ES = -0.19) reach directions. **Conclusions:** No significant changes in YBT reach distances were identified following a competitive field hockey season in healthy Division I female athletes. Because YBT scores remain stable over time including participation in a competitive season, these findings support the use of the YBT as a preseason screening measure that does not need to be repeatedly assessed over the course of a season. These findings are significant because they allow clinicians to minimize repetitive YBT tests without compromising injury prediction capabilities.

Effectiveness of Balance Training and Strength Training Protocols to Improve Strength and Patient-Reported Outcomes

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Context: Individuals with chronic ankle instability(CAI) experience strength deficits, increased fear of re-injury, and perceived instability. Healthcare practitioners use functional rehabilitation to improve these deficits. **Objective:** Determine the effectiveness of strength and balance training protocols on strength and perceived instability in patients with CAI. **Design:** Randomized Controlled Trial. **Setting:** Research Laboratory. **Patients or Other Participants:** Thirty-nine participants with CAI volunteered for this study. Identification of Functional Ankle Instability Questionnaire(IdFAI) determined CAI status. Participants were randomly assigned to groups: Balance Training Protocol (BTP, N = 13, 23.5 ± 6.5 years, 175.0 ± 8.5 cm, 72.8 ± 10.9 kg), Strength Training Protocol (STP, N = 13, 24.6 ± 7.7 years, 173.2 ± 9.0 cm, 76.0 ± 16.2 kg), and Control Group (CON, N = 13, 24.8 ± 9.0 years, 175.5 ± 8.5 cm, 79.1 ± 16.8 kg). **Interventions:** The BTP group completed a hop-to-stabilization balance training, whereas the STP group completed a resistance band and proprioceptive neuromuscular facilitation strength protocol. The CON group completed a mild-moderate bike workout for 20 minutes. Each participant completed their training 3x/week for six weeks. Strength and patient reported outcomes measures (PROM) were tested before(pretest) and after the six-week protocol(posttest). Strength was measured in four ankle directions using the Cybex Dynamometer (HUMAC Norm, CSMi Solutions, Stoughton, MA) in the concentric and eccentric modes at 90°/s. The PROMs included a measure of perceived instability using a Visual Analog Scale (VAS) and a fear of re-injury measure using the Fear-Avoidance Beliefs Questionnaire (FABQ). **Main Outcome Measures:** Concentric (C) and eccentric (E) strength (Nm) were captured in inversion (INV), eversion (EV), plantarflexion (PF), and dorsiflexion (DF); VAS (points) and FABQ (points). Two multivariate repeated measures ANOVAs (strength and PROM) were conducted with follow-up univariate analyses. A priori alpha level was set at $p = 0.05$. **Results:** The strength multivariate identified a significant time by group interaction ($F_{16,58} = 3.56$, $p = 0.001$). Follow up comparisons found significant improvements from pretest to posttest: in the BTP group for INV-concentric (mean difference: 2.27 ± 0.73 Nm, 95% CI: 0.80 to 3.74), INV-E (mean difference: 3.48 ± 0.98, 95% CI: 1.49 to 5.48), PF-C (mean difference: 5.91 ± 1.60 Nm, 95% CI: 2.68 to 9.15), and PF-E (mean difference: 8.55 ± 2.93 Nm, 95% CI: 2.61 to 14.48) and in the STP group for INV-C (mean difference: 2.65 ± 0.73 Nm, 95% CI: 1.18 to 4.12), INV-eccentric(mean difference: 4.28 ± 0.98 Nm, 95% CI: 2.29 to 6.27), EV-eccentric (mean difference: 5.48 ± 0.75 Nm, 95% CI: 3.96 to 7.00), PF-C (mean difference: 4.69 ± 1.60 Nm, 95% CI: 1.45 to 7.92), and PF-E (mean difference: 8.46 ± 2.93 Nm, 95% CI: 2.52 to 14.40). The CON group did not show significant improvements ($p > 0.05$) from pretest to posttest in any strength measure. PROM multivariate did not reveal a significant time by group interaction, however, there was a significant main effect for time ($F_{2,35} = 8.11$, $p = 0.001$). All groups significantly improved from pretest to posttest for the FABQ (mean difference: 4.56 ± 1.26, 95% CI: 2.01 to 7.12) and the VAS (mean difference: 12.77 ± 4.57, 95% CI: 3.51 to 22.03). **Conclusions:** The protocols significantly improved plantarflexion, inversion, and eversion strength. Interestingly, all groups including the control improved in fear-avoidance and perceived instability. Clinicians should incorporate more functional rehabilitation to improve both clinical and perceived deficits associated with CAI.

Lower Extremity Strength, Functional Performance and Limb Symmetry Among Healthy Subjects

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Context: Strength, functional performance and limb symmetry are common objective assessments utilized to help safely and successfully return injured individuals to physical activity following joint musculoskeletal injury. **Objective:** To compare lower extremity strength, functional performance and limb symmetry in healthy participants based on sex (male, female) and level of activity (athlete, non-athlete). **Design:** Observational. **Setting:** Laboratory. **Patients or Other Participants:** A total of 117 healthy participants (72 males, 45 females, mass = 73.67 ± 13.60 kg, height = 1.76 ± 0.12 m, age = 21.44 ± 2.92 years, Tegner score = 8.5) without history of injury within the past 6 months or anterior cruciate ligament reconstruction were included in the study. Participants were identified as an athlete if they were currently a varsity college athlete and a non-athlete if they were recreationally active and not a member of a varsity college sports team. **Interventions:** Participants completed strength and functional tasks bilaterally during a single testing session. Strength tasks included isokinetic knee extension and flexion at 90°/sec and 180°/sec and isometric knee extension and flexion at 90°, Functional tasks included a single leg hop, crossover hop, triple hop, and 6-meter timed hop. **Main Outcome Measures:** Strength measures included maximal voluntary isometric contractions (MVIC, Nm/kg), peak torque (Nm/kg), and average power (W/kg). Functional outcome measures included distance (m) and time hopped (s). Limb symmetry index (LSI), LSI was calculated by the dividing the poorer performing limb by the better performing limb. Participants with LSI values closer to 1.00 were more symmetric. Separate sex by group comparisons of unilateral and LSI outcomes were assessed through 2 x 2 MANOVAs. To summarize our findings, we calculated Cohen's d effect sizes for each observed statistically significant difference and present the range. Higher effect size values indicated males or athletes had higher values. Alpha level was set at 0.05 or less. **Results:** No interactions ($p = 0.10$) or main effects between sex ($p = 0.94$) and activity level ($p = 0.18$) were reported for LSI. Mean LSI ranged between 0.84 ± 0.13 and 0.96 ± 0.04. Main effects for sex were observed for strength ($p < 0.001$) and functional tasks ($p < 0.001$) and for level of activity on functional tasks ($p < 0.001$). Males were stronger [Range d = 0.63-1.54], hopped farther [Range d = 1.52-1.63] and faster [Range d = 1.68-1.67] than females. Athletes and non-athletes had similar strength, but athletes hopped farther [Range d = 0.71-.82] and faster [Range d = 0.87-0.88] than non-athletes. **Conclusions:** Sex and level of activity may not need to be considered when assessing limb symmetry, but different threshold outcomes should be considered based on type of symmetry assessment. Sex and level of activity differences should be accounted for when evaluating strength and functional performance in legs individually.

Free Communications, Rapid Fire Oral Presentations: Case Studies of the Head, Neck, and Spine

Tuesday, June 27, 2017, 9:15AM-10:30AM, Room 371; Moderator: Robb Rehberg, PhD, ATC, NREMT

Vertebral Artery Dissection in a Division I College Football Player

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Background: A 19-year-old male Division I football player with a prior history of two diagnosed concussions presented with headache, dizziness, and significant difficulty ambulating following a head impact. On initial evaluation, the athlete reported two significant head impacts. The first occurred to an unknown head location during a tackling drill. Limb parasthesia gradually developed following this impact and approximately 60-minutes later he sustained a second impact to the facemask. Video review and helmet accelerometer data identify four impacts between 10-40g coinciding with initial onset of symptoms, and one 43.4g impact that precipitated self-removal from practice and reporting symptoms to the medical staff. He experienced significant leftward disequilibrium and was assisted off the field by the athletic training staff. He had two emetic episodes before being evaluated by the team physician, who conferred a concussion diagnosis based on clinical examination. Despite overt signs during field removal, neurological examination revealed no focal deficits, intact cranial nerves, and normal strength and sensation in extremities. Vertigo and nausea prevented the athlete from completing immediate post-injury testing. However, the athlete completed the SAC and BESS three hours post-injury when his status permitted. He completed the SAC, BESS, and a computerized neurocognitive test at 42 hours post-injury while symptomatic, and 8 days post-injury when the athlete reported as asymptomatic. Neurocognitive testing and postural testing revealed no clinically significant differences from baseline at any time point. Symptoms were monitored serially and, in order of cumulative severity, included headache, neck pain, and balance problems. The injured athlete was enrolled in an ongoing clinical research project and, thus, benefited from neuroimaging sequences involved in the study. These scans were performed at 2 time points: 42 hours post-injury and again when the athlete reported no longer experiencing symptoms. Magnetic resonance imaging (MRI) neuroimaging identified a subacute infarct within the right inferior cerebellar lobe with some petechial hemorrhage staining. There was maturation of the infarct without definite increase between imaging sessions. Punctate infarcts were present in the adjacent left inferior cerebellum and right medulla with abnormal loss of right vertebral artery signal void. Upon obtaining the results from the initial scan, the athlete's athletic trainers immediately transported the athlete to our institution's Level 1 trauma center emergency department for neurological consultation as MRI findings included differential of verterbral artery dissection. An MRI angiogram within the emergency department confirmed a vertebral artery dissection and the athlete was placed on anti-platelet medication and retired from contact sports. **Differential Diagnosis:** Concussion, intracranial hemorrhage, traumatic cervical injury. **Treatment:** Anti-platelet medication. Permanently disqualified from contact sport. Referred to stroke specialist for evaluation and monitoring. **Uniqueness:** Existing studies report a very low vertebral artery dissection incidence resulting from sport-related injuries, and there are no other published studies or cases describing vertebral artery dissection in a Division I football player. Further, the most common symptoms of vertebral artery dissection (vertigo, dizziness, headache, and neck pain) are consistent with concussion symptoms and may lead to misdiagnosis in populations where concussions are common, such as contact sports like football. While most vertebral artery dissections result in positive outcomes when treated properly, unidentified or mismanaged vertebral artery dissections may result in stroke, death, or other neurological complications. Most vertebral artery dissections occur in older populations and the long-term effects of vertebral artery dissection in young populations remains unknown. **Conclusions:** Vertebral artery dissections should be considered in the differential diagnosis for patients presenting with a symptom cluster specific to headache, dizziness/vertigo, and neck pain following head trauma, especially in the absence of any other symptoms or clinical deficits. Future research should establish guidelines to rule out vertebral artery dissections during concussion evaluations.

Atlas Subluxation in a Female High School Basketball Athlete

Fitzgerald J, Powers ME, Gildard M: Marist College, Poughkeepsie, NY

Background: A 17-year-old Caucasian female interscholastic basketball player presented with a severe migraine and a sensation of increased pressure in her head. She stated that the symptoms began approximately three weeks prior and had continued to worsen. She rated her pain as ranging from 5/10 to 8/10 and compared the pressure sensation to changes perceived when in an airplane or underwater in a pool. The patient also stated that she had not been sleeping well and had a constant headache that was exacerbated with exercise. The headache and pressure were also provoked by trunk flexion. Additional symptoms included photophobia, blurred vision and diplopia. She stated that she was not experiencing any neurological symptoms and reported no history of prior head or cervical injury. She began taking Excedrin® (acetaminophen, aspirin, and caffeine) to manage the migraines and headaches, however there was no other therapeutic intervention. She also stated that she went to her family physician one week after symptom onset and was referred to a chiropractor. She stated that she did not report to the athletic trainer initially due to fear of being held out of participation. **Differential Diagnosis:** Cerebral aneurysm, encephalitis, muscle tension headache, Tolosa-Hunt syndrome, cervical strain, cervical fracture, occipital headaches. **Treatment:** The patient was referred to a chiropractor as instructed by the physician. Following radiographs, the chiropractor diagnosed her as having an atlantoaxial subluxation (AAS) and performed a reduction using the Atlas Orthogonal procedure. Following reduction, the patient reported back to the athletic trainer and received myofascial release and massage for the upper trapezius and cervical erector group. In the days following initial reduction, the patient presented with occasional headaches during exercise but not to the severity of her original complaint. The patient received two more Atlas Orthogonal treatments from the chiropractor over the next two weeks and continued to receive soft tissue treatment by the athletic trainer. She was able to fully participate in all basketball activities. **Uniqueness:** This case is unique in that there was no known mechanism or predisposing factors. AAS subluxations are normally due to traumatic instances such as falls or blows to the neck or head. When non-traumatic subluxations occur, they are usually associated with cervical or pharyngeal inflammatory conditions, upper airway infection or otolaryngologic procedures, which our patient did not have. Additionally, our patient failed to report cervical pain which is commonly associated with this injury. She also did not have any of the typical clinical signs which include palpable deviation of the second cervical spinous process, spasm of the ipsilateral sternocleidomastoid and inability to rotate the head beyond midline in the contralateral direction. The migraines and vision disturbances she suffered were caused by atlas rotation and the resultant compression of the vertebral artery and decreased cerebral perfusion. The Atlas Orthogonal procedure itself is also unique, as it is not viewed as a typical management procedure. **Conclusions:** Non-traumatic AAS is a rare but dangerous condition and only minimal evidence exists to support etiology and treatment. While this injury often goes unrecognized, it can have severe consequences. While headache alone is a non-specific symptom, cervical assessment should be included with this complaint. Common conservative management strategies include therapeutic modalities such as superficial heat, electrical stimulation and ultrasound, joint mobilizations and massage. Surgical management is sometimes necessary.

Acute Sinus Infection Progressing to Orbital Cellulitis in a Division I Collegiate Equestrian Athlete

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Background: A twenty-year-old female equestrian athlete reported to the athletic trainer with complaints of a sore throat, nasal and sinus congestion, and dyspnea on August 25, 2015. She was referred to her team physician and treated for a sinus infection. Thirteen days later, she presented to the emergency department (ED) with a 102-degree fever, significant congestion, and dyspnea. Chest x-rays were taken and results were normal, thus ruling out pneumonia. The athlete was diagnosed with severe acute sinusitis. Four days following the ED visit, the athlete reported to the athletic trainer with a severely swollen left eye and increased congestion. She was again referred to the team physician, followed by an optometrist, and an ophthalmologist, and finally admitted to the hospital via the ED on September 11th. **Differential Diagnosis:** Cavernous sinus infection, preseptal cellulitis, orbital cellulitis. **Treatment**: Seventeen days after initial presentation and following examination by a physician, optometrist, and ophthalmologist, the athlete was admitted to the hospital and placed on intravenous antibiotics (3g Piperacillin) and pain medication (0.5mg/hr Dilaudid). Evaluation revealed an inability to actively open her left eye and ptosis due to inflammation. However, when the eyelid was held open, the athlete had normal visual acuity of 20/20 for her right eye and 20/25 for her left eye and her pupils were equal, round, and reactive to light. A noncontact tonometry test performed by the optometrist revealed an elevated intraocular pressure of 20.3mmHg in the athlete's left eye as opposed to 15.7mmHg in her right eye. Movement of the left eye in any direction caused pain. A computerized tomography (CT) scan revealed no current abscess behind her left eye. She remained in the hospital for four days and was discharged with orders to continue oral antibiotics and

decongestants. After two follow-up visits with the ophthalmologist, the athlete was referred to an Ear Nose and Throat (ENT) specialist as well as an immunologist. The athlete again underwent CT imaging of her face on November 2nd, revealing nearly complete opacification of her left frontal sinus when compared to the CT scan taken in the hospital on September 11th. Mild chronic mucosal thickening of the paranasal sinuses was apparent bilaterally, but most notably in the left frontal sinus. Intranasal examination by the ENT specialist revealed an idiopathic left nasal septum deviation of 80% inferior turbinate hypertrophy, and visible nasal mucosa edema. On November 23rd, she received a functional, image-guided endoscopic sinus surgery, a septoplasty, and a submucosa resection of the turbinates. One week later, she returned for a follow-up and removal of the post-operative nasal splint. The athlete was allowed to return to mild cardiovascular activity, excluding intense running, jumping and riding, ten days following surgery. Three weeks following surgery, she returned to the ENT specialist for a second post-operative follow up and was cleared for full activity. She also began biweekly allergy injections from her immunologist. **Uniqueness:** Less than two percent of cases of orbital cellulitis are caused by sinusitis involvement of the maxillary and frontal sinuses. However, though rare, orbital cellulitis extending from infection of the frontal sinuses results in permanent vision loss in the affected eye in 11% of cases. This case study is unique, as our athlete presented with severe and chronic frontal sinusitis and temporary vision loss, but presently does not have any permanent serious complications. **Conclusions:** Multiple specialist examinations led to a successful surgical intervention for this athlete. The functional, image-guided endoscopic sinus surgery, to open her frontal sinus cavity and realign her nasal septum, in conjunction with the medication and biweekly allergy injections will potentially decrease risk of future sinus infections.

Maxillofacial and Cranial Bone Fractures in a Male Collegiate Lacrosse Player

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Background: Sports related injury of the maxillofacial region contributes to less than 21% of all maxillofacial injuries, while the remainder are due to traumatic events such as motor vehicle accidents or assault. Mandibular fractures can account for up to 50% of all sport-related maxillofacial fractures and of these about 38% will have at least two fractures of the mandible. In lacrosse, male athletes are required to wear helmets and mouth guards in attempt to reduce the rate of head, face and eye injuries. Regardless of protective equipment, 3% of injuries reported in men's lacrosse were fractures to the head or face. In this case, a 19 year old male lacrosse player was playing defense when he was struck with a ball on the left side of his helmet under the earpiece, after turning away from an offensive player who wound up to take a shot. The ball made direct contact in the region of the mandibular ramus. After the play, he calmly walked off the field, and while spitting blood complained that he lost his bottom, middle tooth. Upon examination by the certified athletic trainer, there was a gap in the inferior tooth line indicating a potential for a luxated tooth. In addition, his range of motion (ROM) at the temporomandibular joint (TMJ) was limited secondary to pain. While performing the squeeze test of the mandible, pain and crepitus were observed indicating a high likelihood of a fracture. Radiographs and a computed tomography (CT) scan revealed three fractures: 1) a complete nondisplaced fracture to the ramus that migrated inferiorly to the angle, 2) a comminuted, displaced fracture of the right parasymphysis region of the mandible, and 3) a comminuted, displaced fracture to the left lateral pterygoid plate of the sphenoid bone. **Differential Diagnosis:** Luxated tooth. **Treatment:** The same day of the injury, the physician performed a closed reduction to realign the mandible at the parasymphyseal region. Post-reduction, the patient's TMJ was wired shut for 4 weeks thus restricting the athlete to a liquid diet. The doctor referred the patient to a nutritionist for guidance on a liquid diet and for management and prevention of a flare up of Crohn's disease. The patient consumed 3,000-3,500 calories daily through shakes which also contained two crushed pills for management of Crohn's disease. After the wires were removed they were replaced with rubber bands, allowing him to consume soft foods for two additional weeks. **Uniqueness:** Sports related maxillofacial fractures are commonly classified into four categories; impact against the ground, another player, the environment and sporting equipment. Impact against another player is the most common cause (80.8%), while impact with equipment is the least likely to occur (4.8%). Of patients diagnosed with a sports-related maxillofacial fracture, only 1% had a mandible fracture with a concomitant midface fracture. Fracture of a cranial bone concurrent with a mandible fracture is very rare with a high lateral impact force, as the forces are typically dissipated across the mandible. **Conclusions:** Helmets in lacrosse are specifically designed to reduce injuries from high impact forces obtained from a ball or stick. However, regardless of wearing a helmet, injuries such as a fracture can still occur to the facial and cranial bones. After a high impact force to the mandible is sustained, if it appears there is a missing tooth of the inferior row, a mandibular fracture should be suspected as a displaced fracture of the parasymphysis can create gapping between the inferior teeth.

Greater Occipital Nerve Block Following a Concussion in Division One Women's Basketball Player

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Background: A 19-year-old Division 1 women's basketball player sustained a concussion following a collision with a teammate. Athlete had an initial symptom score of 60 on the concussion symptom checklist used in the SCAT3™. She suffered from sensitivity to light, dizziness and a headache. Athlete also reported neck pain and muscle spasm accompanying the symptoms. Athlete had no previous history of a concussion. **Differential Diagnosis:** Concussion, mild traumatic brain injury, whiplash **Treatment:** The team physician diagnosed the athlete with a concussion and secondary neck muscle spasm. A brain MRI was ordered after the diagnosis of a concussion and the results were unremarkable. Athlete was initially referred to physical therapy two times per week for eight weeks for cervical manipulation and twelve vestibular therapy sessions for balance training and canalith repositioning, which the athlete believed made her symptoms worse. Athlete was also referred to a speech pathologist for two sessions to work on focus and memory, and occupational therapy two times per week for eight weeks for visual processing and tracking due to slow brain processing. The athlete did well at these tasks, but did not find symptom relief. Further the athlete received academic assistance from Center for Disability Services due to difficulty she was having concentrating. However, she continued to suffer from post-concussion headaches for over one year. These symptoms eventually resulted in a loss of eligibility for the 2013-2014 season. During the June 2014 physicals, the athlete met a spine specialist during pre-participation physicals that suggested greater occipital nerve block injections. The athlete received three occipital nerve injections that were administered one year after the initial concussion incident between June and October 2014. This provided the athlete with complete symptom relief and she returned to full activity in September 2014. On the day the athlete returned to play, she was struck in the jaw, and subsequently received a temporomandibular joint disc injection. A month later the athlete lost her hearing in her left ear due to another blow to the jaw. Currently, the athlete has 70% hearing loss in her left ear, and voluntarily does not perform physical activities that include rapid level changes. **Uniqueness:** The literature for treatment of post-traumatic headaches is limited. In this case, many therapies were used that did not provide the patient with relief of symptoms from post-concussion headaches and dizziness. It was only after the occipital nerve block injections that the patient had resolution of symptoms. Due to the anatomy of the greater occipital nerve and how it lies in the musculature of the neck, it is often associated with headache disorders secondary to head and neck trauma. Greater occipital nerve injections are a safe and effective way to decrease the frequency in which the nerve fires and eliminate the symptoms associated. **Conclusions:** After a collision with a teammate, a Division 1 women's basketball player sustained a concussion that resulted in post-concussion symptoms lasting over a year. The athlete took a redshirt year and did not participate in any sport specific activities. The athlete was cleared in September 2014 and, now, has no headaches or dizziness with an increase in heart rate. The athlete however, avoids physical activities involving level changes, like burpees or touching the line on suicide drills as a cautionary measure to prevent return of symptomology. Athletic trainers should consider greater occipital nerve block injections for patients who have headaches in the pattern of the occipital nerve distribution and get worsening symptoms upon compression.

Spine Pain in an Intercollegiate Football Athlete

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Background: A healthy 20 year old defensive back reported to the AT 1 day post-game complaining of right posterior thoracic pain secondary to direct contact with an opponent. Initial evaluation was absent visual abnormalities; however, palpation elicited diffuse thoracic tenderness with intact neurovascular function. Results of shoulder and lumbar spine testing were WNL. **Differential Diagnosis:** disc pathology, rib contusion, muscle contusion, facet sprain, vertebral fracture. **Treatment:** The patient was conservatively treated and cleared to participate in the final game of the season after successfully completing a battery of functional tests. The patient was instructed to rest over winter break and follow up with the AT if his symptoms persisted. Status post 2 months, the patient developed persistent pain and paresthesia following six weeks of rest. AT follow-up examination identified moderate point tenderness over L3-L4 articular pillar, and right L1-L3 myotome weakness. The patient was referred to the team physician who ordered radiographs. The patient underwent radiographic examination which revealed a vertebral boney cortex disruption. The patient was disqualified from activity and an MRI was ordered which revealed an L4 superior endplate irregularity, and L3-L4 disc degeneration with mild narrowing. The team physician definitively diagnosed the patient with an L4 limbus fracture and prescribed rehabilitation with the AT. Rehabilitation consisted of physical agents to modulate pain, traction and myofascial release to enhance spinal and soft tissue mobility, and gradual progression of therapeutic exercises to centralize symptoms, regain muscular balance, and enhance postural control and stability. Status post 5 months, the rehabilitation program progressed to include explosive core strength exercises, functional progressive activities, and the patient was cleared to begin running with the team. After several

unsuccessful attempts to run with the team, the patient was diagnosed with myofascial pain and facet syndrome secondary to the limbus fracture. The patient was referred to a physiatrist and underwent a facet injection. The patient was disqualified from running and instructed to continue with rehabilitation. Status post 6 months, the patient reported being asymptomatic and was slowly progressed to full team activities over 4 weeks. Status post, 9 months, the patient was cleared for unrestricted activity, continued to complete a core maintenance therapeutic exercise program, and participated in all football activities without complications. **Uniqueness:** A limbus fracture is an injury that is uncommonly reported in the literature. This injury is normally associated with motor vehicle and pedestrian accidents, rather than athletic trauma. This case is unique because the injury did not occur with forced flexion associated with axial compression, but rather, the compression was caused by a hit to the right side of the body. **Conclusions:** A limbus fracture is a bony disruption of the apophyseal ring of the vertebral body at the connection to the annulus fibrous. Specifically, in this case, the injury resulted in an avulsion of bone fragments from the end plate through annulus fibrous, and eventually causing paresthesia. Diagnosing was challenging because the reported pain and physical examination findings did not match the pathology. Also, despite the MRI having fewer line pairs of resolution than a CT scan, the MRI's superior ability to identify indirect signs of a fracture such as edema, hemorrhage, alignment abnormalities, and soft tissue pathology to the ligaments, facet capsules, and pereverebral spaces assisted the medical staff in correctly diagnosing the patient. Due to its uniqueness, there is a gap in the literature identifying the best course of action, but can include conservative treatment, or removal of apophyseal fragments and/or disc material. Successful treatment of this condition was strictly dependent on the patient's circumstances and positive reaction to conservative treatment.

Traumatic Atypical Low Back Pain With Radiculopathy Following a Failed Cheerleading Dismount: A Case Study

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Background: At the time of evaluation, the patient was a 12 year old female cheerleading flyer with an 8 week history of atypical low back pain with radiculopathy after a failed cheerleading dismount. She was performing a stunt and was dropped, landing on her sacrum/coccyx and was unable to stand up immediately following the fall. She was taken by ambulance to a local emergency department where she was evaluated and released. Upon presentation for evaluation by the Athletic Trainer and Physical Therapist, she complained of low back and bilateral lower extremity pain and radiculopathy following the L5 and S1 dermatomes, inability to stand or walk with her heels down without severe pain resulting in toe-walking, and severe pain and paresthesia with heels down. Additionally, she was found to have impaired arthrokinematics and guarding throughout the entire thoracic and lumbar spine, decreased strength and endurance, decreased ROM of the lumbar spine, positive straight leg raise, positive slump test, positive prone knee bending, significant lumbar muscle spasm and muscle guarding. **Differential Diagnosis:** Low back pain, lumbosacral facet syndrome, lumbar disc herniation, lumbar fracture, piriformis syndrome, sacroiliac joint pain, coccygeal fracture, sacroccygeal dislocation, sacral fracture, intrapelvic malignancy and/or metastatic lesions. **Treatment:** Subsequent evaluation by the pediatric specialized departments of orthopaedic surgery, neurosurgery, physiatry and neurology yielded similar findings. An MRI of the lumbar spine demonstrated small effusions at the L3 facet joints, minimal annular bulge at L4-5 without mass effect, L5-S1 broad-based annular bulge and tear with moderate bilateral neural foraminal stenosis abutting both exiting L5 nerve roots. An MRI of the entire spine was ordered and essentially read as normal. All specialties felt the type and severity of pain was atypical of the findings on the MRI which did not correlate with the patient's clinical evaluation. In addition to physical rehabilitation, she was treated with non-steroidal anti-inflammatory, muscle relaxer and antispastic medication, pain reliever, steroid taper, nerve pain medication and spinal epidural injection. While working in rehabilitation with the AT and PT, it was found that the patient's pain and radiculopathy was significantly reduced, and in some cases resolved, when the patient performed exercises in supine position. She also demonstrated full, painless ROM and flexibility of the lumbar spine and lower extremities when supine and many of her neurological tests, including straight leg raise, were negative. However, when the same exercises and tests were performed while upright or prone, the patient's symptoms would return. A request for an upright MRI was made by the AT, PT and parents to orthopaedic surgery. The upright MRI was performed and demonstrated what was thought to be a horizontal sacrum without associated lumbar or pelvic fracture. This anterior rotation of the sacrum increased nerve tension while the patient was upright, explaining her nerve tension signs, however this rotation was reduced to near normal alignment when the patient was in the supine position. For most MRI imaging, the patient is supine on the exam table, which would have reduced the patient's horizontal sacrum, thus making the MRI appear essentially normal. **Uniqueness:** Although the mechanism of injury is common in the sport of cheerleading, low back pain and radiculopathy on physical exam despite essentially normal diagnostic examination is atypical. This demonstrates the importance of physical examination in different positions, including sitting/standing, prone, and/or supine, for injuries affecting the spine. When available, performing

diagnostic testing in pain-provoking positions is also beneficial, such as in this case. **Conclusions:** Thorough evaluation of injuries is essential, especially when diagnostic and physical examination do not correlate. The involvement of multiple specialties can be beneficial, however appropriate testing is key to proper diagnosis.

Chronic Low Back Pain in an Adolescent Athlete

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Background: A 15 year old female who participated in cheerleading, soccer and track (discus, high jump) experienced low back pain with activity over a two year period. It increased to the point where she went to a chiropractor. No x-rays were taken. Manual manipulations were done with no relief of her pain. She continued her activities with pain however no activity modifications were implemented. **Differential Diagnosis:** Low Back strain SI Dysfunction Spondylolysis Spondylolisthesis **Treatment:** She was evaluated by a Sports Medicine trained physician when she began experiencing right outer thigh numbness/tingling and low back numbness. Activity worsened her symptoms. Pain was rated as 8/10. On physical examination her ROM was within normal limits. She had a palpable midline spinous process step off at L5 and S1 with mild tenderness to palpation. She was non tender over her sacroiliac joints. She had a positive right sided straight leg raise, positive right sided FABRE, decreased sensation of her right medial foot/great toe and 5/5 motor strength in bilateral lower extremities. X-rays of the lumbar spine showed a Grade 4 spondylolisthesis at L5-S1. At this time she was told to stop all athletic-type activity and referred to an Orthopaedic Pediatric surgeon. After reviewing her x-rays and having the same results on physical examination, it was decided to proceed with a L5-S1 fusion and L5 laminectomy. She is now 11 months status post-surgery. She denies any numbness or tingling in the lower extremities. She does have some residual hyperesthesia over her bilateral lateral thighs. She continues to have slight tenderness and paraspinal spasms over the lumbar musculature. She was cleared for non-impact aerobic activity, light weight lifting, and horseback riding at a walking speed. She was told to avoid excessive low back flexion or extension exercises. Physical therapy was initiated for core and paraspinal strengthening. **Uniqueness:** Spondylolysis occurs in 6% of the general population. Approximately 75% of these will develop spondylolisthesis. Athletes, who participate in sports involving extreme spinal motion, particularly lumbar extension and rotation, have an increased prevalence of these two diagnoses. The progression from spondylolysis to spondylolisthesis is common in these adolescent athletes. An accurate diagnosis with an evaluation, radiographs and activity modification may prevent this progression. This athlete had a two year history of low back pain that progressed to radicular symptoms finally causing her to seek an evaluation from a Sports Medicine trained physician. When she was initially seen by a chiropractor, a thorough physical examination with radiographs and activity modification may have led to an earlier diagnosis of a possible spondylolysis or had her seek further evaluation by a Sports Medicine trained healthcare provider. **Conclusions:** This athlete is a highly active individual who competed in sports with a high impact load, lumbar extension and rotation. Over a two year period she developed low back pain that increased until radicular symptoms and numbness caused her to seek a more thorough examination by a Sports Medicine trained healthcare provider. This led to a surgery that may limit her return to full activity of the sports she enjoys. It is important for healthcare professionals such as athletic trainers and physicians to recognize the importance of educating coaches and parents of these adolescent athletes on the risk factors involved in their specified sports. Athletes must also report pain and/or symptoms early to an athletic trainer or physician. An earlier diagnosis of the presented athlete's chronic back pain and activity modification with proper rehabilitation may have prevented surgery.

Lumbarization Accompanied by Spina Bifida Occulta in a Female Soccer Player

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Background: The subject in this case is a 14-year-old female soccer athlete (ht =154.94cm, wt =51.26kg). She presents with complaints of low back pain for approximately one month. The subject did have a brief involvement with track and field events including long jump. Symptoms occurred after track season and are not believed to be a contributing factor since the subject was asymptomatic during the track season and did not become symptomatic until she resumed soccer activities. Physical exam demonstrated point tenderness along the paraspinal musculature bilaterally and at L4-L5. There was no erythema, ecchymosis, and no noted deformity. She had normal ROM with active forward flexion, rotation and lateral flexion. Pain was noted with extension with a positive stork test. Neurological exam was negative. She reports having used ibuprofen for pain and has not had much relief. **Differential Diagnosis:** The subject was believed to have generalized low back pain and paraspinal muscle spasm. Also included in the differential diagnosis was the possibility of a spondylolisis or spondylolisthesis. **Treatment:** Two weeks after initial evaluation she went to our sports medicine clinic for examination and radiographs were obtained. Plain radiographs and MRI demonstrate a sixth functioning lumbar vertebra, this vertebra has been numbered L6. AP radiographs showed spina bifida occulta on L6 and a spondylolisis on could be seen on the oblique view. A lumbarization can be seen with or without disc space between S1and S2. MRI also showed a bilateral spondylolisis of L6 without any spondylolisthesis. The subject was treated conservatively with a course of physical therapy, rest from soccer activities, and prescription strength naproxen. Therapy consisted of core, trunk, and lumbar stabilization and strengthening exercises including McKenzie exercises. Therapy was done at the subjects' high school under the supervision of her certified athletic trainer five times per week for three weeks. Return to competition was permitted once pain was a zero on a scale of ten and symptoms had subsided. She was able to ease back into activities starting with a running progression program, followed by sport specific drills (i.e. Dribbling, shooting, passing), and finally full contact practice under the supervision of her athletic trainer. She was counseled on maintaining a core strengthening program through out her years of competitive play along with the importance of a light warm up and stretching of hip and back musculature and icing after activity. **Uniqueness:** Lumbarization of the first sacral vertebra is significantly more uncommon than a sacralization occurring in approximately 3.4-7.2% of the population. The presence of any type of LSTV accompanied by spina bifida occulta in the sacral region is even more rare, 0.02%. **Conclusions:** While the presence of lumbosacral transitional vertebrae is a fairly common finding, the prevalence of a full lumbarization vs. a sacralization is less common. The prevalence of lumbarization varies in the literature. On study found transitional vertebra were found in 32.3% of subjects and, only 5.9% presented with lumbarization. Another study involving subjects with prolonged low back pain found two cases of LSTV accompanied by spina bifida. While there is no evidence that these abnormalities are the primary cause of low back pain in individuals with these malformations, it has been speculated that they can certainly be a contributing factor. LSTV may be correlated to low back pain due to the altered biomechanics at the L5/S1 junction. Presence of confirmed LSTV and unexplained low back pain is referred to as Bertolotti's syndrome. Patients with LSTV especially accompanied by any other congenital abnormality at the lumbosacral junction should maintain a core strengthening program in order to reduce symptoms and retain normal functionality.

Retrolisthesis of the Lumbar Spine in a Female Multisport High School Athlete: A Case Report

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Background: Retrolisthesis in the lumbar spine can lead to structural instability which means that treatment must be managed carefully and differently than a typical spondylolisthesis, which displaces anteriorly. A 15 year old female athlete who participated in both volleyball and softball, who had no prior history of back injury, began presenting with low back pain during daily activity. After multiple months of progressive pain which lead to cessation of participation, the athlete sought out orthopedic care. Examination by an orthopedic physician led to an official diagnosis of a grade 1 retrolisthesis of the L5 vertebrae with a right pedical stress fracture and a posterior disc protrusion between L4 and L5. **Differential Diagnosis:** Lumbar Compression Fracture, Lumbar Degenerative Disk Disease, Lumbar Facet Arthropathy, Disk Herniation, Facet Joint Pathology. **Treatment:** After determining that surgery was not necessary, the patient was completely removed from participation and referred for physical therapy. Restrictions were placed on lumbar flexion in all physical therapy and during her home exercise program. Core stabilization was a major focus during the entire rehabilitation process. This program included body blade exercises, straight leg raises without weights, bird dog, and pelvic neutral tilt exercises. After the six weeks of therapy the patient returned to the orthopedic with instructions to continue therapy for two times a week for four more weeks. She was also advised to continue with her home therapy program. Therapy was then recommended for once a week for a period of 13 weeks. In March of 2014 the orthopedic and the physical therapist decided to discontinued outpatient therapy but progressed the home therapy program. The patient was also given a prescription of 7.5MG tablets of Meloxicam for inflammation, which was not used at

any point. Due to subtle low back pain the athlete was held out of participation until May of 2014. Once she was pain free and functional she was cleared for participation. **Uniqueness:** This case presents a young athlete who suffered from retrolisthesis, stress fractures, and a herniated disk in the lumbar spine. While spondylolisthesis and stress fractures are common in adolescence, the combination of these with a disk herniation is not common. **Conclusions:** Adolescent athletes playing multiple sports at the same time over the course of a year, without adequate rest, can result in extensive pathologies like described in this case study. Research related to rehabilitation of retrolisthesis is limited, therefore this case study should add relevant missing knowledge. Regardless of displacement direction, conservative management for mild spondylolisthesis cases shows that pain can be reduced, and range of motion can increase, with general strengthening and functional activities. While severe cases that present with a displacement of 50% or more may do better with surgical treatment, it seems that mild cases of 50% or less vertebral displacement can be effectively treated with conservative methods similar to this case. This patient showed significant improvements and was able to fully return to play with no complications after 9 months of rehabilitation. Based on the presentation of this case, limiting adolescent participation earlier upon presentation of LB pain, may prevent further complications such as a herniated disk. In conclusion, because lumbar extension exercises were not limited due to the posterior displacement of the vertebral body, it seems that the disk herniation did not cause significant complications in the rehabilitation process.

Concussions in a Single Youth Football League: A Case Series

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Background: Thirteen youth football players from one self-governed, southeastern regional football league were evaluated for concussion from August through September within one season. Players were 9-13yo (11±1) an on average 57.3 inches tall, and 95.7 lbs. Six of the 13 teams in the league had players diagnosed with a concussion. Four (30%) of the concussed players were on the same team. None of the 13 players had a history of a concussion. Two (15%) of the players were on medication for attention deficit disorders. Five (38%) of the players had a mechanism of head to ground contact. The remaining eight players (62%) had head to head contact mechanisms. Six (46%) occurred while being tackled, 6 (46%) while making a tackle, and 1 during blocking. Seven (54%) of the concussions occurred during practice, and 5 (46%) occurred during a game. The average number of symptoms was 11 ± 4 out of 34 (SCAT+SCAT-Child) as documented in the online injury surveillance system. A headache and dizziness were the most common symptoms affecting all thirteen players. Additional examples were: 11 (85%) experienced difficulty concentrating, 8 (62%) experienced sensitivity to noise, 3 reported sadness, 2 players had numbness/tingling, and 1 player experienced loss of consciousness and amnesia. The season began in mid-July and contact practices in August. Coaches attend one educational meeting at the start of the season and were not required to be CPR certified. The league in general held two contact events a week (1 practice, 1 game) and one non-contact practice. **Treatment:** Each player was evaluated by the on-site certified athletic trainer (AT). They were then referred to a physician of the parent's choice. One concussed player was sent via ambulance to the emergency department to rule out a cervical spine injury. School accommodations were given to each player by the physician. Once each player was cleared by a physician, they began a five-day return to play (RTP) protocol supervised by the AT. The league mandated that all players need clearance from the physician, and the AT, before returning to competition. **Results:** The average number of days before being cleared to start the RTP protocol was 10, and for full RTP was 19 (Range: 12-39). Only two players had recurring symptoms during the RTP protocol which required them to re-start the protocol. One player reported being "afraid to get hit again" during the RTP protocol and another did not RTP for the remainder of the season (parental decision). **Uniqueness:** Concussions are a common injury in athletics, with football having the largest estimate of reported concussions. Concussions compose 4-10% of athletic related injuries in youth, high school, and college athletics, with youth having the lowest risk. In this league, concussions composed over 30% of the documented injuries within the league and occurred within a short amount of time. Restriction of contact time has been suggested to decrease concussion incidence but in the current case series the type of contact may have played a significant role. In general, the RTP time for the majority of concussions across competitive football is 7-13 days. In the current case series, the average RTP was almost double. **Conclusions:** Thirteen youth football players were diagnosed with a concussion in 2 months by an AT. Concussion rates and symptom numbers appear to be high in this football league. A conservative approach needs to be taken when clearing a youth athlete for play because of a possible longer recovery time. This case series supports the need for ATs in youth football settings and more research on symptoms, RTP, and reasons for higher rates of concussions in some youth football leagues.

Athletic Trainer Integration in US Air Force Basic Training

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Context: As the leading contributor to missed military training time and medical attrition from training, musculoskeletal injuries significantly affect operational readiness. Reducing injury morbidity among military recruits could minimize disruptions in the training pipeline, decrease the associated costs, and improve the health and fitness of individuals entering the armed forces. **Objective:** This project was designed to evaluate the operational and cost impact of embedding certified athletic trainers (ATCs) in a U.S. Air Force training squadron. The a priori expectation was that increased access to musculoskeletal care would decrease costs associated with medical care and attrition. **Design:** This on-going project compares basic trainees in an intervention squadron to two control squadrons. As a population-based intervention trial, we utilize extant random allocation of recruits into the three squadrons. **Setting:** The study assesses the impact of an embedded sports-medicine, athletic training-based medical paradigm within US Air Force basic military training. **Patients or Other Participants:** 12,373 trainees were included in the study from Jan-June 2016, 7,440 in the control squadrons (43,475 training weeks) and 4,933 in the experimental squadron (28,252 training weeks). Trainees are randomly assigned to squadrons upon in-processing at JBSA-Lackland. **Interventions:** Faculty at the University of the Incarnate Word opened an athletic training clinic within the 323rd squadron at JBSA-Lackland just prior to January 1, 2016. The clinic is staffed by two full-time athletic trainers who care for as many as 1,200 trainees at a time. The intervention directs independent duty medical technicians on base to redirect trainee reports of musculoskeletal injuries to the athletic training clinic. Earlier diagnosis, daily access to therapy, and scheduling flexibility around required training classes improves trainee injury management. US Air Force preventative medicine group of the 59th medical wing collected data through their electronic medical records database. **Main Outcome Measures:** As a population study, researchers used relative risk ratios to determine significance. Global and musculoskeletal-specific attrition rates, medical hold referral rate (resulting in time out of training and delayed graduation), and injury rates to include stress fracture development were all considered. **Results:** Experimental and control squadron results (reported in this order for each) Attrition rates: 4.66% and 6.09%; 0.76 (0.67, 0.88); $p < 0.0001$ Medical Hold Referral rate: 2.28% and 3.21%; 0.71 (0.59, 0.86); $p < 0.0001$ Attrition due to msk injury: 0.95% and 1.16%; 0.82 (0.59, 1.12); $p = 0.1286$ Injury from Stress fracture: 2.14% and 2.53%; 0.85 (0.68, 1.05); $p = 0.0568$ **Conclusions:** Embedded ATCs in U.S. Air Force Basic Military Training reduce attrition and time out of training due to injury and therefore the net financial impact is positive. This program is early in its implementation and analysis will continue to delineate the longitudinal impact of ATCs in a military training environment.

Fatigue Diminishes Static and Dynamic Balance in Firefighters

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Context: Musculoskeletal injuries due to overexertion, slips, falls, and jumps account for over half of all work-related injuries in the firefighting population. The occupational tasks of firefighters often include quick bouts of intense activity while wearing firefighting specific personal protective equipment (PPE). The effect of these activities, while wearing PPE, on measures of static and dynamic balance is currently unknown. **Objective:** To evaluate the effects a short bout of physical activity on static and dynamic balance in firefighters. **Design:** Repeated measures, single cohort. **Setting:** Fire stations. **Patients or Other Participants:** Forty-one male firefighters (age = 37.1 ± 8.1 y; height = 182.7 ± 8.4 cm; mass = 98.8 ± 14.3 kg; years of experience = 11.0 ± 6.2 y; leg dominance = 34 R, 7 L; FADI = 98.7 ± 2.6 points) completed this study. **Interventions:** Participants completed the Functional Agility Short-Term Fatigue Protocol. The activities included step-ups, L-drill, vertical jumps, and agility ladder, repeated four times. Participants completed the static and dynamic balance tasks before and after completing the Functional Agility Short-Term Fatigue Protocol in full firefighting specific PPE(mass of PPE = 23.8 ± 2.1 kg). **Main Outcome Measures:** Our independent variable was time (before and after activity) and our dependent variables included anterior, posterior-medial, and posterior-lateral reach distance (cm) measured with the Y Balance TestTM bilaterally, and rectangular displacement area (cm2) and average displacement velocity

(cm/s) in a double- and dominant single-legged stance measured with a multi-axial force platform. Participants wore firefighting specific PPE during all pre- and post-intervention measurements. We utilized separate dependent t-tests to compare outcome measures. Significance was set at $p < 0.05$ a-priori. **Results:** We identified a significant decrease in anterior reach of the right limb following a single bout of physical activity protocol (mean difference = -1.5 ± 2.9 cm; 95% CI = -2.4, -0.5; d = 0.5; p = 0.003). No significant differences in mean reach were found in either limb during the posteromedial or posterolateral reach tasks. We found a significant increase in rectangular displacement area after physical activity in both double-legged (mean difference = 1.6 ± 3.2 cm2; 95% CI = 0.65, 2.7; d = 0.46; p = 0.002) and single-legged (mean difference = 2.3 ± 4.4 cm2; 95% CI = 0.9, 3.6; d = 0.51; p = 0.002) stances. We found a significant increase in average displacement velocity post-activity during double-legged (mean difference = 0.21 ± 0.28 cm/s; 95% CI = 0.1, 0.3; d = 0.85; p < 0.001) but not during single-legged stance. **Conclusions:** Following a single bout of physical activity, dynamic and static balance diminishes in firefighters wearing PPE. These data suggest that a bout of intense activity negatively impact balance and may increase risk for slips, trips, and falls at the fireground. Training and injury prevention interventions designed to improve balance in the firefighting population should occur in job-specific PPE and include training during a fatigued state to more functionally replicate the occupational demands firefighters face. Future research should be conducted to examine the effect of sustained work on firefighter balance while donning occupation-specific PPE.

The Prevalence, Risk, and Rate of Musculoskeletal Injuries and Sudden Illnesses in Marching Band and Color Guard Members: A Systematic Review

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Context: Marching band (MB) and color guard (CG) are popular physical activities; unlike sponsored athletic programs there is limited medical coverage despite the risk of injury and illness. **Objective:** Systematically review the literature to determine the prevalence/incidence, risk or rate, and type of musculoskeletal injuries (MSI) and sudden illnesses (SI) reported during activity among high school and collegiate marching bands and color guard. **Data Sources:** Articles were identified from: PubMed, CINAHL, MEDLINE, Physical Therapy and Sports Medicine Collection, and ScienceDirect using search, ["marching band" OR "color guard" OR "marching athlete" AND injury] from January 1990 to October 2016, resulting in 141 articles. **Study Selection:** Following screening (title, abstract), six articles were reviewed. Four met inclusion criteria: (1) peer-reviewed, cross-sectional studies, (2) high school or collegiate-aged members, (3) available abstract, (4) English language, (5) included prevalence/incidence, risk/rate of MSI and SI. **Data Extraction:** Two reviewers independently assessed studies' level of evidence (LOE) and quality using Oxford Center for Evidence Based Medicine (2009) and STrengthening the Reporting of Observational Studies in Epidemiology (STROBE) instruments. Data of interest: subjects, injury/illness prevalence/incidence and classification (descriptive statistics [mean, SD]), and risk/rate of injury/illness (eg. odds ratio, risk, CI:95%; reported/calculated) for MSI and SI. **Data Synthesis:** Four studies met inclusion criteria (LOE = 2b). STROBE scores ranged from 12-23 (0-32 technique; average = 16.875 ± 6.875). Pooled sample size 2,272, in collegiate (n = 3) and high school (n = 1) aged members with MB only (n = 1), MB and CG (n = 2), and unidentified (ie., MB or CG) members (n = 1) over different season lengths. All studies agree MB and CG are strenuous activities with significant potential for lower extremity (LE) MSI. One study found overall injury rate for one week of band camp was 124.03/1,000 exposures, while LE injury rate was 68.18/1,000 exposures. Injury rates in another study ranged from 21/100 students for piccolo players to .05/100 students for snare drummers. In comparison, MB and CG sustained 0.7 and 1 injury per hr. during practice (149/216.1) and performances (19/19.2); while marching performances resulted in 3.6 injuries per hr. (15/4.2). Incidence of injury during band camp was reported at 267 (267/178 = 150%) and 423 (423/224 = 188%) over two seasons. Final study reported MSI prevalence at 25% of participants. Overall, LE MSI (n = 3) ranged between 27%-85% of reported injuries; illnesses were 11-13%. Limitations of studies include: (1) inconsistent definitions, (2) varying methods, (3) self-reported data, (4) poorly reported data, and (5) sample size. **Conclusions:** Results strongly indicate that MB and CG are likely to sustain LE MSI and the nature of the activity predisposes members to certain types. MB and CG is an athletic activity often performed by unfit individuals, thus athletic trainers should be present to provide injury prevention and manage MSI and SI.

Injury History, Severity, and Medical Care for Athletes Participating in Brazilian Jiu-Jitsu

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Context: Brazilian Jiu-Jitsu (BJJ) is a relatively new sport in the United States, and is rapidly gaining popularity. While it appears that BJJ has a high risk of injury, there is still little information on the types and mechanisms of injury for BJJ athletes, and no information about the access to medical care for BJJ athletes. **Objective:** To assess demographic information, participation rates, injuries and medical care in BJJ athletes. **Design:** Descriptive. **Setting:** Six local BJJ gyms. **Patients or Other Participants:** 104 BJJ players completed the questionnaire (104 male, age: 33.0 ± 8.91 years, height: 178.6 ± 8.4 cm, mass: 86.0 ± 16.8 kg). **Interventions:** A questionnaire was developed to assess the following information: demographics (age, gender, belt rank), participation (months of experience, frequency of practice), injury history (frequency of BJJ-related injury in past 12 months, location and mechanism of injury (MOI), submission related to injury, time lost in practice and work), and medical care (was medical care sought, medical provider(s) and location(s) seen, medical diagnosis(es)). The questionnaire was provided to potential participants at participating gyms and returned via postal service. **Main Outcome Measures:** Descriptive statistics were calculated for all variables. Pearson's chi-square tests were used to compare participants' self-report of a current or prior injury to various demographic variables (a£0.05). **Results:** Participants reported widely varying experience (total experience: 68.3 ± 44.84 months (range = 12-168 months), average practice hours per week: 6.9 ± 4.82 hours/week). Seventy-eight participants (75.0%) reported 136 current or resolved injuries in the past year. 113 cases (83.1%) occurred during practice. The knee (35 cases, 26.5%) and the neck (14 cases, 10.6%) were the most frequently injured body parts. Players sought medical attention for 59 injuries (43.4%), primarily from physicians (50%) and in physician clinics (62.3%). Strain (15 cases, 27.3%), sprain (9 cases, 16.4%), and cartilage damage (7 cases, 12.7%) were the most common diagnoses. Submission-related motions (52 cases, 41.6%) were the most common MOI. Arm bar (7 cases, 13.2%) was the most common submission technique related to injury. Players missed an average of 35.9 ± 60.1 days of practice and 1.6 ± 6.7 days of work due to BJJ-related injury. A significant association was found between frequency of practice and number of players who reported at least 1 injury in the past year ($n = 103$, $X^2 = 5.661$, $p = 0.017$) and between players who reported a history of injury in the past year, and the presence of a current injury ($n = 103$, $X^2 = 6.325$, $p = 0.012$). **Conclusions:** A majority of BJJ athletes reported suffering an injury in the past year, which resulted in time loss from work and practice. However, only about half of injured players sought medical care. Gym owners and BJJ athletes may want to consider easier access (either on-site or nearby) to qualified medical professionals who can help in the treatment and prevention of injury.

Epidemiological Characteristics of Musculoskeletal Injuries in Thoroughbred Horse Racing

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Context: Professional Jockeys are high level athletes participating in a sport that puts them at a particularly high risk for musculoskeletal injuries. The aim of this study is to report injuries sustained by jockeys participating in Thoroughbred Horse Racing in the United States. Very little is known about the nature and risk factors of these injuries. **Objective:** The objective of this study is to describe characteristics and identify modifiable risk factors for musculoskeletal injuries in jockeys. **Design:** This study is a descriptive epidemiological study. **Setting:** Aggregate injury data were collected from reported incident reports from racetracks throughout the United States. **Patients or Other Participants:** Data were collected and entered in the Jockey Injury Database. An incident report was completed if a jockey was separated from horse thrown from a horse during a race or received medical treatment as a result of a race related injury. A total of 975 male and 64 female jockeys (Experience level 11.0 ± 9.5 years, Range 0.16 - 30 years) were included in the database with 1054 reported incidents. **Interventions:** Data were obtained from the Jockey Injury database between September 2014 and September 2016. **Main Outcome Measures:** Descriptive statistics were used to identify frequency and percentages of musculoskeletal injuries based on the location on the track, nature of the injury, cause of injury, and the region of the injury. **Results:** The majority of incidents occurred at the start (352/34.08%), in the stretch (251/24.30%) and in the final turn (170/16.45%) respectively. Although the majority of the nature of the resulting 407 injuries were not specified (108/33.75%), strain/sprains (77/24.06%) and fractures (75/23.44%) were also among the most common. An overwhelming majority of injuries were caused by being injured during a fall (326/80.10%) followed by

being injured on the horse (26/6.39%) and being trampled by the horse (14/2.44%). The most commonly injured regions were upper extremity injuries (98/34.39%), lower extremity injuries (74/25.96%) and head/facial injuries (56/19.65%). Of those who were injured, 31% did not return the same day while 7.90% returned the same day. **Conclusions:** Professional jockeys are at a high level of risk when competing in thoroughbred horse racing. The results of this research help establish characteristics to better understand the injury risk to jockeys. This information can help us identify modifiable risk factors and work towards reducing risk in thoroughbred horse racing.

A Retrospective Analysis of Jockey Injuries in the United States

Crots JM, Quintana C, Gribble PA, Mattacola CG: University of Kentucky, Lexington, KY

Context: Due to the high intensity and pace of the sport, professional horse jockeys are at a high risk for injury. However, there is limited previous research on measures aimed to reduce injury rates, specifically concussion rates in this athletic group. The aim of this study was to identify injury rates, specifically concussion rates, sustained by jockeys participating in thoroughbred horse racing in the United States. **Objective:** To describe characteristics and modifiable factors in jockeys who have sustained a concussion for the purpose of identifying areas for risk reduction and improved safety. **Design:** Cross-sectional descriptive epidemiological analysis **Setting:** Injury data were collected from competitions held at horse racetracks in the Midwest and East Coast of the United States. **Patients or Other Participants:** A total of 1054 reports were collected. Of these, a total of 45 jockeys were diagnosed with a concussion event. **Data Collection and Analysis:** Data were obtained from the Jockey Injury database between September 2014 through September 2016. Descriptive statistics were used to identify frequency of injury and percentages based on gender (male, female), helmet type (LAS, Caliente, Champion, Charles Owens, U of F, Excalibur, GPA Sport, International), track type (dirt, turf, synthetic), track condition (fast/firm versus sloppy/muddy/good), jockey experience [GPA4] (<10 years, >11 years), & age of horse. **Results:** Of the 45 reported concussions during this period, 36 males and 8 females sustained a concussion, with one case going unreported. The majority of concussions when compared by helmet occurred wearing the LAS Helmet (16/35%) which is consistent with the prevalence of jockeys wearing said helmet. The remaining concussions when observed by helmet type were distributed evenly. Concussion rates observed on dirt (29/64%) surfaces were higher versus turf and synthetic surfaces (13/29%). More concussions occurred in fast/firm conditions (36/80%) than sloppy/muddy/good conditions (6/13%). Injury rates were almost double (28/62%) in less experienced jockeys (< 10 years' experience) versus more experienced jockeys (13/29%) (> 11 years' experience). Nearly half of observed incidences were in races where the horse was above three years of age (25/56%). **Conclusions:** The results of this research establish injury characteristics that can be used to better understand equipment, conditions, and trends that contribute to an increased risk of concussion. These identified modifiable risk factors can be a target area for reducing concussion rates in horse jockeys.

Emerging Setting: Athletic Trainers Positively Impact Orthopaedic Trauma Patients' 12 Week Functional and Perceived Functional Outcomes

Zdziarski LA, McCelland J, Vasilopoulos T, Sadasivan KK, Hagen JE, Patrick M, Dluzniewski A, Sleeth C, Chang C, Vincent HK, Horodyski MB: University of Florida, Gainesville, FL

Context: Low functional gains and poor perception of physical functional occur when orthopaedic trauma patients are not provided adequate communication and explanation of their injury course. Patients struggle with kinesiophobia and altered functional perceptions. A potential solution to optimize patient outcomes is to include an athletic trainer (AT) as a facilitator in the orthopaedic trauma team. **Objective:** Determine the effect of athletic trainers as members of the orthopaedic trauma team on patient functional outcomes and perceptions of physical functional in acute hospital and postoperative clinical settings. **Design:** Randomized controlled clinical trial. **Setting:** In-patient Level-I orthopaedic trauma hospital and associated out-patient clinic. **Patients or Other Participants:** Patients admitted to the orthopaedic trauma service without subdural hematoma or pre-existing psychological illness. **Interventions:** Patients were randomized into one of two groups based on facilitator type: (AT or a non-medically trained facilitator [non-AT]; skill level of a medical assistant). AT or non-ATs provided patients with the "Transform 10" program; these 10 steps included guidance on self-advocacy, mind-body medicine strategies, and rehabilitation to recover from their orthopaedic trauma. **Main Outcome Measures:** Perceived physical function: Tampa Scale of Kinesiphobia-11 (TSK-11), Patient Reported Physical Function (PROMIS Function). Functional Testing: Average Grip Strength (GS), Lower Extremity Gain Scale (LEGS); and Communication Assessment Tool (CAT). All measures were assessed at 2, 6, and 12 weeks postoperatively. PROMIS Function and GS were assessed prior to discharge from the hospital. Repeated-measures general linear modeling was used to determine group differences in function. Kurskal-Wallis was used to assess CAT score difference between groups. **Results:** Thirty-eight subjects were enrolled, 12 with AT facilitators and 26 with non-AT facilitators. Average age and BMI were 43.0 ± 18.8 years and 29.8 ± 8.07 km/m2, respectively. At baseline, patients in the AT group had double the number of fractures and four times as long a stay in ICU. For TSK-11 scores, significant time by facilitator group interaction existed, where the AT group demonstrated progressive reduction in TSK scores over time ($p = 0.013$). A significant main effect of time on PROMIS Function existed, Wilks' Lambda = 0.110, $F_{(3,11)} = 29.8$, $p < 0.001$. No significant interactions or main effects existed between groups for any functional testing (LEGS $p = 0.237$ and Grip Strength $p = 0.136$). While not significant, the AT group had higher CAT scores than non-AT. Perceived physical function at 12 weeks significantly predicted actual function (LEGS) $R2 = 0.157$, $F_{(1,26)} = 4.65$, $p < 0.001$. **Conclusions:** At 12 weeks follow-up AT facilitators provided an additional benefit compared to non-AT by reducing kinesiophobia during patient recovery. Lower TSK-11 and higher CAT scores suggest that ATs can enhance the quality of the patient experience through communication about their injury and recovery process. Data from this study suggest that ATs have a positive impact on orthopaedic trauma patients and should be included in their care teams.

Free Communications, Rapid Fire Oral Presentations: Measuring Functional Performance

Tuesday, June 27, 2017, 12:00PM-1:00PM, Room 371; Moderator: Janet Simon, PhD, ATC

Validation of the Sport Fitness Index for Quantification of Injury Effects on Functional Status

Baker CS, Gross M, Shelton S, Colston MA, Wilkerson GB: University of Tennessee at Chattanooga, Chattanooga, TN

Context: The NCAA documented 182,000 injuries among athletes participating in 15 sports over a 16-year period. Research has demonstrated that targeted interventions for modifiable risk factors can prevent injury. The Sports Fitness Index (SFI) is a 10-question survey created to numerically represent global function in order to assess an athlete's risk of injury. **Objective:** To validate the SFI as a tool for injury risk prediction and to assess its potential value for representation of change in functional status among high school and college athletes. **Design:** A cohort pre-post-test study. **Setting:** Field Setting **Patients or Other Participants:** Cohorts of 84 high school football (HS FB) players (15.2 ± 1.2 years; 179.5 ± 8.2 cm; 81.0 ± 16.6 kg), 73 NCAA Division I college football (College FB) players (19.9 ± 1.3 years; 185.5 ± 6.5 cm; 104.6 ± 20.2 kg), and 113 NCAA Division I non-football (College Other) athletes; 40 males (19.4 ± 1.4 years; 175.2 ± 7.0 cm; 76.8 ± 15.9 kg) and 73 females (19.3 ± 1.2 years; 169.2 ± 8.0 cm; 64.6 ± 7.5 kg) participated in the study. **Interventions:** SFIs and self-reported injury history were administered during pre-participation screenings (PPE) and following the conclusion of the regular season for all cohorts. Injury history data was obtained from self-reported history for prior 12 months for PPE and post-season injury history was limited to the beginning of pre-season. Follow-up was limited to participants who were present for post-season survey administration. **Main Outcome Measures:** SFI scores (0-100) and injury history data at pre-season and post-season were used for analysis. Receiver operating characteristic (ROC) analyses identified both retrospective and prospective SFI cut-points and cross-tabulation analyses were performed to assess associations between SFI score and injury occurrence. **Results:** Substantial associations between PPE SFI score and prior injury for all 3 cohorts, with comparable cut-points (84-86/100). Retrospectively derived cut-points demonstrated predictive value of subsequent injury during season, with comparable sensitivity and specificity values for HS FB and College FB, but poor specificity for College Other: HS FB score ≤84 (n = 55, sensitivity = 69, specificity = 50); College FB score ≤86 (n = 54, sensitivity = 71, specificity = 52); College Other score ≤86 (n = 78, sensitivity = 77, specificity = 36). Prospectively derived cut-points improved injury prediction sensitivity for HS FB and College Other (83 and 85 respectively). Association of injury occurrence with change in SFI score from PPE to post-season was evident. A change in SFI score from PPE to post-season of ≥ 4-points was associated with an injury having occurred during the season for all 3 cohorts. **Conclusions:** The results confirm that persisting effects of previous injury elevate risk for subsequent injury during sport season. The optimal SFI cut-point for injury prediction appears to differ for specific populations defined by sport and level. The SFI appears to provide a meaningful contribution to injury risk assessment in high school football players and NCAA Division I college athletes.

Performance Tracking Over a Single Season in Male Collegiate Soccer Players

Donner C, Norte GE, Resch JE, Hart JM: University of Virginia, Charlottesville, VA

Context: Activity monitoring in soccer has been employed to reduce injury risk and optimize performance. Injury history and fatigue adversely affects performance and may be different among player positions with varying levels of athletic experience. Wearable technology has been used to establish performance metrics and to analyze on-field performance however, there is a lack of data analyzing changes over an entire season. **Objective:** To compare measures of sport performance in male collegiate soccer players based on time of season, position, experience level, and injury history. **Design:** Cross-Sectional. **Setting:** Field. **Patients or Other Participants:** 21 male collegiate Division I soccer athletes. **Interventions:** Each athlete was fit with an OptimEyeS5 athletic monitoring device (Catapult, Inc.) and monitored throughout the regular season. **Main Outcome Measures:** Player load (cumulative measure of exertion) normalized to minutes played and changes in acceleration were recorded. Changes in acceleration occurred with every positive shift in velocity by at least 4 miles-per-hour (e.g. 12-to-16 mph = 1 change). Means with 90% confidence intervals were calculated to identify changes in total player load or acceleration changes over the season. Separate 1 x 3 ANOVAs were used to compare player load and acceleration change by time of season (early: games 1-4, middle: games 5-10, late: games 11-14), position (forward, midfielder, defender), and injury history (none, current season injury, prior injury history). Independent t-tests were used to compare player load and acceleration change by level of collegiate experience (1-2 vs.

3-4 years). Data for 14 regular season games were analyzed and reported. Player Load is a unitless ratio, accelerations are presented as cumulative counts. **Results:** Total player load did not change over the season. Forwards (13.9 ± 3.1 vs. 10.5 ± 1.4; $p < .001$) and midfielders (12.5 ± 1.1 vs. 10.5 ± 1.4; $p = .015$) experienced higher player load than defenders. Player load was higher in players with less collegiate experience (14.1 ± 2.5 vs. 11.4 ± 0.5; $p = .002$). Players with no injury history experienced higher player load than those with a current-season (17.9 ± 6.1 vs. 11.4 ± 0.8; $p < .001$) or prior injury(17.9 ± 6.1 vs. 11.8 ± 0.7; $p < .001$). Total number of accelerations did not change over the season. Forwards (57.6 ± 17.9 vs. 35.7 ± 10.0; $p < .001$) and midfielders (48.2 ± 9.4 vs. 35.7 ± 10.0; $p = .015$) experienced more acceleration changes than defenders. Players with less collegiate experience had more acceleration changes during the middle (52.5 ± 8.1 vs. 41.2 ± 4.7; $p = .032$) and late (60.0 ± 7.4 vs. 41.2 ± 4.7; $p < .003$) season compared to early. Players injured during the season had more acceleration changes than players with no injury history (56.4 ± 11.7 vs. 39.7 ± 10.1; $p < .001$) and those with a prior history (56.4 ± 11.7 vs. 46.1 ± 6.6; $p = .008$). **Conclusions:** Position, experience, and injury history are important factors that influence the load experienced by collegiate soccer players. These data may be used to help facilitate rest and recovery, and optimize performance over the season.

Screening Ballet Dancers Using the Functional Movement Screen

McPherson AM, Gaerte C, Neumann JL, Docherty CD: Indiana University, Bloomington, IN; St. Vincent's Sports Performance, Indianapolis, IN

Context: The Functional Movement Screen (FMS) test has been widely-used within the sports medicine community to evaluate movement patterns and to assess potential injury risk. Ballet dancers are reported to have high incidence of injury; therefore, injury prevention is highly-valuable. The FMS has not been evaluated for its use in a ballet population to date. **Objective:** To evaluate the utility of the FMS test to predict injury in a ballet dancer population. **Design:** Cohort Study. **Setting:** Collegiate ballet major program. **Patients or Other Participants:** 71 ballet majors at an elite Midwestern university ballet program (male: n = 13, female: n = 58; age = 19.88 ± 1.40years, height = 141.95 ± 62.76cm, weight = 57.86 ± 9.69kg). **Interventions:** All dancers completed the seven FMS tests (Deep Squat, Hurdle Step, In-Line Lunge, Shoulder Mobility, Active Straight-Leg Raise, Trunk Stability Push-Up, and Rotational Stability) in standard fashion during their annual wellness screen. Each test was scored on a four-point integer grading scale of 0-3, performed ≤ 3 times, and the best score was used for calculation of the total score. Injury records were collected for the period of 6-months post-test. Participants were assigned to one of two groups: injured (a participant sustained an injury that required medical attention), and uninjured. **Main Outcome Measures:** Total FMS score, injury status. All alpha levels were set a priori at $p < 0.05$. **Results:** The mean score for all dancers on: Deep Squat, Hurdle Step, In-Line Lunge, Shoulder Mobility, and Active Straight-Leg Raise was 2.08 ± 0.649. The mean of the Trunk Stability Push-Up was 1.62 ± 0.663; and Rotational Stability = 1.51 ± 0.630. No significant difference existed between the injured (mean = 16.17 ±1.64) and uninjured (mean = 15.69 ± 1.34) groups for the Total FMS score ($t71 = -1.30$, $p = .199$). ROC identified the area under the curve as 0.60, indicating that the total FMS score does not help to predict risk of sustaining an injury. **Conclusions:** Ballet dancers demonstrated average Total FMS scores lower than collegiate athlete averages reported in the literature, but greater than the widely-accepted cut-off score of 14. Utility is questionable due to no specific Total FMS score identifying individuals at risk for injury. The FMS test should be used cautiously within the ballet population, and researchers should continue to develop reliable, dance-specific screening tools.

Recreational and Competitive Athletes' Perceptions of Functional Activity Limitations Using the Patient Specific Functional Scale Following Orthopedic Injury

Valier AR, Williams RM, Overlin A, Cozzi AL, Welch Bacon CE: A.T. Still University, Mesa, AZ; Hedley Orthopaedics Institute, Phoenix, AZ

Context: Implementing patient-rated outcome measures are becoming common practice following injury to capture health-related quality of life and functional limitations. Measuring the patients' perspective identifies the impact the injury has on the ability to perform desired activities, is vital for patient-centered care and can assist clinicians in identifying or altering treatment approaches. **Objective:** To qualitatively explore how patients participating in recreational and competitive sports perceive activity limitations following injury. **Design:** Cross-sectional. **Setting:** Outpatient clinic. **Patients or Other Participants:** A convenience sample of 141 patients (51 = males, 90 = females, age = 16.15 ± 5.56 years) participating in recreational or competitive sports seeking treatment for an orthopedic injury. **Data Collection and Analysis:** The Patient Specific Functional Scale (PSFS) was used to assess changes in patient condition and the impact the injury posed on the patients' ability to achieve a desired activity. The PSFS was administered to patients during clinical office visits following an orthopedic injury. The PSFS is a self-reported scale that asks patients to identify 3-5 activities that are impacted by the injury and further instructs patients to rate the difficulty to perform those tasks on a scale of 0 (unable to perform) to 10 (no difficulty). Themes and categories of reported activities were determined via consensus of a four-person research team. Each researcher independently coded the activity data and created a preliminary codebook. The research team then met to discuss and finalize a consensus codebook that richly captured the activity data themes. Triangulation was achieved via the inclusion of multiple researchers to decrease researcher bias. **Results:** Three main themes emerged from data analysis. First, patients defined primary activity limitations according to day-to-day tasks. This theme included three categories: (a) basic functions (e.g., walking, chores), (b) work-specific tasks, and (c) school-specific tasks. The second main theme that emerged was functional movements, which included three categories: (a) total body movements (e.g., squats), (b) upper extremity movements (e.g., shoulder, elbow movements) and (c) lower extremity movements (e.g., knee, leg movements). The third main theme was identified as a sport-specific category with three categories, including (a) task/movement (e.g., jump), (b) general sport (e.g., baseball), and (c) activity (e.g., the act of doing something). **Conclusions:** Recreational and competitive athletes identify primary activity limitations following injury according to basic functions, functional movements and sport-specific categories. These findings highlight the breadth of impact an injury has on functional ability, with areas identified beyond sport participation. Clinicians should use the PSFS to ensure that activity limitations most important to patients are revealed and addressed throughout care. Further research should explore whether the main themes identified in the PSFS are captured by other patient-reported outcomes measures with defined response options. Clinicians should continue to monitor patient specific outcomes to improve overall patient care.

Functional Performance Measures Increase During a High School Sports Season

Sabol T, Grooms DR, Yom J, Starkey C, Onate JA, Simon JE: Ohio University, Athens, OH; Ohio State University, Columbus, OH

Context: An estimated 12 million athletes between the ages of 5 and 22 years sustain a sport-related injury annually, leading to approximately $33 billion in healthcare costs. Functional performance testing is commonly used to determine return to play following an injury. However, it is unclear whether changes in functional performance are seen over the course of an athletic season. **Objective:** Examine whether changes in functional performance occur in a cohort of healthy high school athletes. **Design:** Cohort Study. **Setting:** High school gymnasium. **Patients or Other Participants:** Seventeen male football players (16.3 ± 1.1 years, 177.6 ± 7.4 cm, 83.6 ± 14.2 kg) and 13 female volleyball players (15.4 ± 0.9 years, 162.8 ± 7.7 cm, 68.3 ± 19.5 kg) participated across three testing sessions. Individuals who had sustained a time-loss injury during the season were excluded. **Interventions:** Participants completed the single-leg anterior reach (SLAR) and single-leg hop for distance (SLHOP) at three time points (pre-season, mid-season, and post-season). At each time point each individual completed the SLHOP for three trials for each leg. Participants had to maintain postural control, no hopping or putting their hands on the ground, upon landing for at least 2 seconds. For the SLAR each participant performed three trials for each limb. While maintaining a single-leg stance, the individual reached with the free limb and pushed the reach indicator in the forward direction as far as possible. The maximum value for each variable at each time point was normalized to leg length and was used for analysis. **Main Outcome Measures:** The dependent variables were SLAR normalized distance for right and left legs, and SLHOP normalized distance for right and left legs. The independent variables were time (pre-season, mid-season,

and post-season) and group (football and volleyball). A multivariate repeated measures ANOVA was conducted. Follow up one-way repeated measures ANOVA's were conducted if the multivariate test was significant. The alpha level was set a priori at $p < 0.05$ for all analyses. **Results:** The multivariate repeated measures ANOVA was significant for time ($F = 3.902$, $p = 0.007$) and group ($F = 3.648$, $p = 0.019$). The interaction time*group was not significant ($p = 0.779$). Follow up one-way repeated measures ANOVA's indicated all four dependent variables were significant for time ($p < 0.001$). Specifically, reach and hop distances were significantly increased from pre-season to post-season (SLAR right 73.9% vs. 82.7% of leg length), (SLAR left 74.5% vs 82.6% of leg length), (SLHOP right 178.1% vs 185.9% of leg length) and (SLHOP left 172.8% vs 182.8 % of leg length). Approximately an 8% increase was found from pre-season to post-season for all measures. **Conclusions:** Functional performance testing is commonly used for return to play decision making. Clinicians should consider changes that are naturally occurring throughout a sports season as our participants increased their SLAR and SLHOP.

The Comparative Effects of Ankle Bracing on Functional Performance

Newman TM, Vairo GL, Buckley WE: Athletic Training and Sports Medicine Research Laboratory, Department of Kinesiology and Department of Orthopaedics and Rehabilitation, The Pennsylvania State University, University Park, PA

Context: An abundance of literature exists focusing on the efficacy of braces in preventing ankle sprains in young, healthy and physically active populations, there is a scarcity of evidence specific to the impact of these apparatuses on functional performance. **Objective:** To determine if ankle braces affect functional performance measures when compared with an unbraced condition in a young, healthy and physically active population? **Data Sources:** Articles were obtained through following databases; PubMed, The Cochrane Library, CINAHL, PEDro, and SPORTDiscus using the terms semi-rigid brace, lace-up brace, ankle, and functional performance. Criteria for inclusion consisted of targeting research that was at a minimum of Level II evidence. Articles needed to be published in English within the previous 15 years. **Study Selection:** Thirty-two articles were initially identified; however, only four articles met inclusion criteria for appraised in this work. Randomize controlled trials were scrutinized with a PEDro score. The Downs and Black's revised checklist was used for assessing methodological quality of articles. **Data Extraction:** Data was evaluated and analyzed by the authors of this study. Measures analyzed for this study included; ankle ranges of motion, balance, sprint and agility times, vertical jump heights, and performance on sport specific activities. **Data Synthesis:** Most functional performance measures evaluated in this review were heterogeneous, and all could not be directly compared; however, post-hoc analyses were conducted via Cohen's d effect size with 95% confidence intervals to evaluate trends in the data. Ankle braces were grouped as lace-up, semi-rigid, or Seattle Ankle Orthotic (SAO). Inversion ROM decreased while wearing all bracing conditions, but was most affected while wearing an SAO brace d = -2.00 (-2.69, -1.31). Plantarflexion ROM decreased while wearing all bracing conditions, but was most affected while wearing a lace-up brace d = -1.23 (-1.84, -0.61). Eversion ROM decreased while wearing a lace-up brace d = -0.77 (-1.36, -0.18) and semi-rigid brace d = -1.15 (-1.76, -0.54). A balance deficit was found while wearing semi-rigid ankle braces during the modified BASS test, d = -1.26 (-2.22, -0.30), but aided balance while wearing a lace-up brace on the same task, d = 1.83 (0.79, 2.87). **Conclusions:** Current data indicates young, healthy and physically active individuals may experience varied performance effects when executing specific functional performance tasks while wearing ankle braces. Generally, bracing does not appear to significantly impair performance on most functional tasks; however, decrements were noted to yield increases in agility run time, and decreases in vertical jump height. A subsequent analysis noted a brace may result in decreased ankle PF, DF, EV, and IV ROM, which may underpin noted performance deficits. A grade of B or moderate level of evidence exists demonstrating that ankle braces may have varied impacts on functional performance measures.

Prophylactic Bracing Has No Effect on Lower Extremity Alignment or Functional Performance

Hueber GA, Hall EA, Sage BW, Kingma JJ, Docherty CL: Indiana University, Bloomington, IN; University of South Florida, Tampa, FL

Context: Prophylactic ankle bracing is commonly used during physical activity. Understanding how bracing affects jumping and landing biomechanics is critically important when discussing both injury prevention and sport performance. **Objective:** To determine if prophylactic ankle bracing affects lower extremity mechanics compared to an unbraced ankle during the Landing Error Scoring System Test (LESS) and Sage Sway Index (SSI). **Design:** Crossover study. **Setting:** University Athletic Training research laboratory. **Patients or Other Participants:** Thirty participants (15 males, 15 females, 21 ± 4.14 years, 176.13 ± 9.45 cm, and 73.12 ± 14.81 kg) were recruited to participate in the study. Inclusion criteria for participation were physically active for more than 20 minutes at least 3 times per week, no history of ankle injury within the past month, and no history of a severe ankle injury within the past six months. Exclusion criteria for participation were a history of surgery, fracture, or injury in lower extremity or back in the past three months, or any current medical conditions that could affect balance. **Interventions:** Following a 10-minute bike warm-up, participants completed the LESS and the SSI during a braced (ASO EVO Quatro Brace, Med Spec, Charlotte, NC) and an unbraced condition. The order of brace condition was counterbalanced for all participants. The LESS is a clinical assessment that focuses on the biomechanics of jumping and landing. The SSI is an assessment that evaluates functional performance, coordination, and proprioception. **Main Outcome Measures:** Total errors were recorded for the LESS. Total errors and time (seconds) were recorded for the SSI. For statistical analysis, separate repeated measures ANOVA with one within subjects' factor at two levels (braced and unbraced conditions) was performed for each dependent variable (LESS, SSI-Errors, and SSI-time). A priori alpha level was set at $p < 0.05$. **Results:** Results for the LESS yielded a significant difference between the braced and unbraced condition ($F_{1,29} = 5.92$, $p = 0.02$). Specifically, participants had fewer errors in the braced condition when compared to the unbraced condition (mean difference = 0.63 ± 0.26, 95% CI: 0.10 to 1.17 errors). Conversely, no significant differences were identified between the braced and unbraced conditions for either the number of errors ($F_{1,29} = 0.05$, $p = 0.82$, $\eta p 2 = 0.01$, power = 0.06) or time ($F_{1,29} = 0.05$, $p = 0.83$) of the SSI. **Conclusions:** It appears that prophylactic ankle bracing can improve lower extremity alignment during a jump-landing task. Conversely, the brace had no impact on postural stability during a hopping task. Therefore, this study supports the use of ankle braces in the clinical setting without impacting postural stability, yet improving lower extremity biomechanics.

Free Communications, Rapid Fire Oral Presentations: Lower Extremity Symmetry Following Anterior Cruciate Ligament Reconstruction

Wednesday, June 28, 2017, 8:00AM-8:45AM, Room 371; Moderator: Brian Pietrosimone, PhD, ATC

Inter-limb Comparison of Knee Mechanics During Running Following ACL Reconstruction

Pamukoff DN, Vakula MN, Moffit TJ, Choe K, Montgomery MM: Department of Kinesiology, California State University, Fullerton, CA

Context: Quadriceps dysfunction is implicated in knee osteoarthritis development following anterior cruciate ligament reconstruction (ACLR), partially due to its influence on aberrant walking biomechanics that may accelerate cartilage degradation. However, limited data are available on the influence of quadriceps function on running gait. **Objective:** To examine the association between quadriceps function and running kinematics, and to compare knee mechanics during running between the injured and uninjured limb of individuals with unilateral ACLR. **Design:** Cross-Sectional. **Setting:** Biomechanics Laboratory. **Patients or Other Participants:** 28 individuals with unilateral ACLR (78% female; age = 22.1 ± 3.1 years; body mass index = 23.9 ± 4.1; time since ACLR = 45.5 ± 29.3 months; 14 patellar tendon; 7 hamstring tendon; 7 allograft; International Knee Documentation Committee Score = 84.2 ± 9.3) participated in this study. **Interventions:** Participants completed 5 running trials per limb in a random order at a self-selected speed while 3-dimensional kinematics (240Hz) and kinetics (2400Hz) were recorded. Quadriceps function was assessed by a maximal voluntary isometric knee extension. **Main Outcome Measures:** Dependent variables included sagittal and frontal plane knee angles at heel contact, maximum sagittal and frontal plane knee angles and moments during the stance phase, sagittal plane joint excursion, and maximal quadriceps strength and rate of torque development (RTD). External joint moments were normalized to a product of body weight (BW) and height, and strength data were normalized to body mass for analysis. Paired samples t-tests were used to compare inter-limb differences (α=0.05), and partial correlation accounting for running speed was used to assess the association between quadriceps function and running biomechanics. **Results:** Injured limbs had lesser maximum knee flexion angles (48.7 ± 7.4° vs 53.1 ± 6.2°, $p < 0.01$), knee flexion excursion (29.1 ± 3.2° vs. 32.0 ± 3.8°, $p = 0.02$), external knee flexion moments (0.17 ± 0.04 vs. 0.19 ± 0.04 %BW x height, $p = 0.01$), quadriceps strength (2.56 ± 0.42 vs. 2.75 ± 0.30 Nm/kg, $p = 0.042$), and RTD (38.12 ± 13.27 vs. 47.81 ± 17.99 Nm/sec/Kg, $p = 0.032$) compared to uninjured limbs. There was a trend towards lesser knee flexion angles at heel contact in injured compared to uninjured limbs (20.5 ± 8.0° vs. 22.9 ± 7.2°, $p = 0.11$). No differences were observed between limbs in frontal plane angles or moments. Quadriceps strength was associated with knee flexion angle at heel contact ($r = 0.50$, $p = 0.01$), and with maximal knee flexion angle during the stance phase ($r = 0.55$, $p < 0.01$). Quadriceps strength was not associated with joint moments or frontal plane angles, and RTD was not associated with any biomechanical variable. **Conclusions:** Our findings indicate that injured limbs have lesser knee flexion, and smaller external knee flexion moments during running compared to uninjured limbs in individuals with unilateral ACLR. Reduced external knee flexion moments indicate an impaired ability to attenuate ground reaction force, and may contribute to altered joint loading that is associated with osteoarthritis development. Greater quadriceps strength is associated with greater knee flexion during running, and improving quadriceps strength may mitigate altered running biomechanics following ACLR.

Hip Strength and Pelvis Kinematic Asymmetries and Knee Injury and Osteoarthritis Outcome Score in Competitive Female Basketball Players After Anterior Cruciate Ligament Reconstruction: A Pilot Study

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Context: Hip strength and pelvis motion may play important roles in reducing the risk of noncontact ACL injuries. Moreover, self-reported questionnaires focus on psychometric measurements for patients with knee injuries. However, hip strength and pelvis kinematic asymmetries and self-reported questionnaires in patients after ACL reconstruction (ACLR) are not well understood. **Objective:** To determine hip strength and pelvis kinematic asymmetries, and self-reported questionnaires for patients after ACLR. **Design:** Cross-sectional study. **Setting:** Laboratory. **Patients or Other Participants:** Fifteen competitive female basketball players who had had ACLR (age: 19.27 ± 2.02 years; height: 166.37 ± 6.49 cm; weight: 63.05 ± 8.63 kg). **Interventions:** Bilateral isometric contraction of hip flexion (FLX), hip extension (EXT), hip abduction (AB), hip external rotation in a seated position, and hip external rotation in a prone position were measured. Pelvis kinematics during a single-legged medial drop landing (SML) was examined using a motion analysis system. Participants stood on the non-ACL injured limb or the ACLR limb on a 20 cm box. They jumped 30 cm in a medial direction, then landed on a force plate

on the same leg. The knee injury and osteoarthritis outcome score (KOOS) was selected as the self-reported questionnaire. **Main Outcome Measures:** The average of two trials of hip strength was normalized to body weight (%BW). The pelvis anterior tilt (AP) and lateral flexion angle at the initial contact (IC) (VGRF > 10N) and peak (maximum VGRF) during the SML were calculated. Bilateral KOOS subscales were reported. The paired sample t-test was used to determine hip strength and pelvis kinematic asymmetries ($\alpha < 0.05$). The Wilcoxon signed-rank test was used to compare the KOOS subscales ($\alpha < 0.05$). **Results:** There were significant differences in FLX (non-injured side (NIS), 37.17 ± 6.90% BW vs. ACLR side (ACLRS), 35.31 ± 6.75% BW; P = 0.04)), EXT (NIS, 39.77 ± 7.28% BW vs. ACLRS, 35.36 ± 8.52% BW; P < 0.01); AB (NIS, 19.97 ± 4.79% BW vs. ACLRS, 18.55 ± 5.12%BW; P = 0.01). There was a significance difference in the AP at IC (NIS, -8.37 ± 4.22° vs. ACLRS, -9.86 ± 4.76°; P = 0.03). All KOOS subscales for the ACLRS were significantly lower than those for the NIS (pain: P < 0.01; symptoms: P = 0.04; ADL: P = 0.04; sport: P < 0.01; quality of life: P < 0.01). **Conclusions:** Female basketball players after ACLR have weaker hip strength, more AP during the SML on the ACLRS, and lower KOOSs for the ACLRS. The differences in hip strength, pelvis kinematics and KOOSs between the sides may indicate that underlying problems exist in athletes after ACLR. According to the current results, decreasing hip strength and pelvis kinematic asymmetries and KOOS may help to reduce risk factors of ACL re-injury for females after ACLR.

Landing Error Scoring System Symmetry in Individuals With and Without a History of ACL Reconstruction

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Context: The Landing Error Scoring System (LESS) is a valid and reliable tool for assessing knee injury risk via jump-landing biomechanics. It remains unclear if the LESS is sensitive to biomechanical asymmetries that have been reported in individuals with a history of knee injury. **Objective:** To determine whether biomechanical asymmetry can be assessed using the LESS among participants with and without a history of ACL reconstruction (ACLR). **Design:** Descriptive laboratory study. **Setting:** Laboratory. **Patients or Other Participants:** Nineteen physically active participants were enrolled in this study including 10 participants with unilateral, primary ACLR (sex = 8F/2M, age = 19.6 ± 1.2 years, BMI = 24.1 ± 2.2 kg/m2), and 9 healthy participants (sex = 6F/3M, age = 22.5 ± 2.9 years, BMI = 23.1 ± 1.8 kg/m2). **Interventions:** None. **Main Outcome Measures:** Participants performed 3 jump-landings from a 30-cm high box that was placed at a distance equal to half of their body height from a target which was marked on the floor. Upon landing, participants immediately jumped vertically for maximum height. All trials were recorded concurrently with one video camera positioned anteriorly and two cameras positioned laterally to enable bilateral evaluation of the landing. The LESS utilizes 22 item scoring criteria to assess movement quality during a jump landing. A greater number of errors indicates great injury risk. The limb with a history of ACLR was compared to the poorer performing limb within the healthy control group and the uninvolved limb was compared to the better performing limb. Between group comparisons where made using the Mann-Whitney U test and within group between limb comparisons were made using the Wilcoxon Signed Rank Test. **Results:** Medians and associated ranges (median [total range]) were calculated for LESS scores. LESS scores for ACLR participants were not significantly different than healthy controls when the involved limb was compared to the poorer performing limb among healthy controls (ACLR = 6.0 [9.0], Healthy = 5.0 [9.0], P = 0.11) or when the uninvolved limb was compared to the better performing limb among healthy controls (ACLR = 6.0 [9.0] , Healthy = 4.5 [8.0], P = 0.36). There were no significant between limb differences within the ACLR group (P = 0.41) while a significant difference was present in healthy controls (P = 0.01). **Conclusions:** ACLR participants did not exhibit between limb asymmetry or significantly worse LESS scores when compared to healthy control participants. These findings are not consistent with previous research regarding landing kinematics after ACLR. Despite these findings, the ACLR group included 7 participants who displayed a LESS score greater than 6 on each least 1 limb which indicates that a majority of these individuals are at elevated risk for subsequent ACL injury. Based on these findings, the LESS may not be an appropriate clinical tool to measure subtle movement asymmetries that are commonly present after ACLR.

Participants at Return to Sport (RTS) After Anterior Cruciate Ligament Reconstruction (ACL-R) Demonstrate Differences in Lower Extremity Energy Absorption Contribution and Limb Symmetry Index Compared to Healthy Controls

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Context: Restoration of symmetrical quadriceps strength and joint loading in patients who have undergone ACL-R is often difficult. The relative contribution of the hip, knee and ankle joint while loading and the relationship to quadriceps strength at time of return to sport (RTS) is unclear. **Objective:** To compare energy absorption (EA) contribution of the hip, knee and ankle joints during a jump landing (JL) task and quadriceps strength asymmetry at RTS for post-operative ACL-R versus healthy controls (CON). **Design:** Case-control study. **Setting:** Hospital based outpatient clinic. **Patients or Other Participants:** Twenty-six ACL-R participants who were at time of RTS (Age = 15.6 ± 1.7 yrs; Ht = 1.7 ± 7.8 m; Mass = 65.6 ± 12.1 kg) were compared to 26 age, sex, limb, and activity-matched healthy controls (CON) (Age = 15.5 ± 1.7 yrs; Ht = 1.6 ± 6.6 m; Mass = 62.0 ± 13.0 kg) **Interventions:** Net power of the hip, knee, and ankle joints was assessed while participants performed three separate JL tasks. Isokinetic quadriceps strength at 60 deg/sec was measured using an isokinetic dynamometer. All measurements were collected bilaterally. Limb dominance was defined prior to testing as the preferred limb used to kick a ball. The injured limb of the ACL-R group was matched to the limb of the control group based upon the side of dominance. **Main Outcome Measures:** Energy absorption of the hip, knee, and ankle joints were normalized to height and weight, and the contribution of each joint was calculated in relation to the total EA (EA of all joints) during the loading phase of the JL task. EA is expressed clinically as eccentric loading. The quadriceps strength was averaged across five trials and the limb symmetry index (LSI) was calculated for the ACL-R (LSI = (involved/uninvolved)*100), and for the CON group (LSI = (minimal/maximal)*100). Separate independent t-tests were calculated to examine the differences between groups in EA contribution of each joint and quadriceps strength LSI. ($\alpha \leq 0.05$). **Results:** For the injured limb, ACL-R participants demonstrated significantly greater EA contribution at the hip (ACL-R = .54 ± .2; CON = .38 ± .2; p = .007) and less ankle EA contribution (ACL-R = .17 ± .1; CON = .24 ± .1; p = .011) compared to the matched CON participants. For the uninjured limb, ACL-R participants demonstrated significantly greater EA contribution at the hip (ACL-R = .47 ± .2; CON = .36 ± .2; p = .045) and less ankle EA contribution (ACL-R = .20 ± .1; CON = .25 ± .1; p = .038) compared to the matched CON participants. The quadriceps LSI was significantly less in the ACL-R group compared to the matched CON group (ACL-R = 70.6 ± 15.8; CON = 88.3 ± 8.9; p < .001). No other significant differences were observed. **Conclusions:** ACL-R participants demonstrate different eccentric loading strategies during a JL task at time of RTS compared to matched controls. Deficits in LSI may contribute to avoidance of the knee joint and greater usage of the hip and ankle. Increasing quadriceps strength may improve symmetry between the hip, knee and ankle joint EA strategy.

Comparison of Unilateral and Symmetry-Based Outcomes in Patients With ACL Reconstuction and Those With Meniscus Pathology

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Context: Functional assessment is a hallmark of clinical evaluation after knee joint injury. Information is limited regarding individuals with a history of meniscus pathology which is most common cause of knee surgery among active individuals. **Objective:** To determine the impact of ACLR and meniscus pathology on unilateral and symmetry-based measures of functional performance as compared to healthy controls. **Design:** Descriptive laboratory study **Setting:** Laboratory **Patients or Other Participants:** Twenty-five physically active participants were enrolled in this study including 10 healthy participants (sex = 7F/3M, age = 22.5 ± 2.9 years, BMI = 23.1 ± 1.8 kg/m2), 10 participants with unilateral, primary ACLR (sex = 8F/2M, age = 19.5 ± 1.2 years, BMI = 24.1 ± 2.1 kg/m2), and 5 participants with unilateral, primary meniscus pathology (sex = 3M/2F, age = 19.3 ± 0.5 years, BMI = 23.0 ± 2.1 kg/m2). **Interventions:** None **Main Outcome Measures:** Participants completed a series of functional tests including the Star Excursion Balance Test (SEBT) and a battery of single leg hop tests including the hop for distance, triple hop, and crossover hop tests. For the SEBT, reach distances were normalized to leg length (% leg length) while hop distances were not normalized (cm) as is consistent with previous literature. Limb symmetry indices (LSI) were calculated by dividing the poorer performing limb by the better performing limb in the healthy group and by dividing the injured limb by the healthy limb in the ACLR and meniscus pathology groups. Participants with LSI values closer to 1.00 were interpreted as having optimal limb

symmetry. Between group (injured vs. healthy) comparisons of affected limb functional performance as well as LSI were made using independent samples t-tests. Additionally, between group (healthy vs. ACLR vs. meniscus) comparisons of affected limb functional performance as well as LSI was made using one-way ANOVA and significant differences were further investigated using Tukey's post-hoc testing. **Results:** Participants with a history of injury performed significantly worst on the hop for distance (Healthy = 170.3 ± 19.4 cm, Injured = 140.4 ± 29.8 cm, P = 0.01) when compared to healthy controls with no other significant between group differences (P > 0.05) for the affected limb or LSI. When healthy, ACLR, and meniscus pathology participants were compared, there were significant differences for affected limb SEBT anterior reach (Healthy = 66.2 ± 5.6%, ACLR = 61.1 ± 4.1%, Meniscus = 66.5 ± 3.9%, P = 0.05) and hop for distance (Healthy = 170.3 ± 19.4 cm, ACLR = 140.9 ± 29.6 cm, Meniscus = 139.4 ± 35.0 cm, P = 0.04); however, no significant between group differences were revealed on post-hoc testing. **Conclusions:** Participants with a history of ACLR and participants with a history of meniscus pathology have similar persistent functional limitations within the affected limb when compared to healthy control participants. Among both groups, limb symmetry measures may not adequately identify participants experiencing functional limitations following knee joint injury. Valid and accessible functional assessment tools are key to making confident decisions regarding a safe and timely return to activity after knee injury.

Free Communications, Rapid Fire Oral Presentations: This is Your Brain on Ankle Sprains: Central Nervous System Alterations in Chronic Ankle Instability Patients

Wednesday, June 28, 2017, 9:00AM-10:00AM, Room 371; Moderator: Alan Needle, PhD, ATC

Effects of Acute Ankle Sprain on Spinal Excitability of Lower Leg Muscles During Upright Standing

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Context: Spinal excitability of lower leg muscles following acute ankle sprain (AAS) has been found to be altered in the prone position, which provides insight into muscle dysfunction associated with AAS. However, the implication of the finding may be limited because it may not reflect ankle function in a weight-bearing condition where spinal excitability may differ from the relaxed, non-bearing condition. **Objective:** To assess spinal excitability of lower leg muscles in patients with AAS while standing. **Design:** Case-control **Setting:** Research laboratory **Patients or Other Participants:** Nineteen subjects with AAS within 72 hours of the injury onset (10 females; age = 21 ± 2.7 years; height = 173.2 ± 9.2 cm; mass = 71.7 ± 11.7 kg) and 19 healthy controls without any history of ankle sprain (10 females; age = 22 ± 2.2 years; height = 170.8 ± 9.2 cm; mass = 68.9 ± 14.2 kg) participated. **Interventions:** Spinal excitability was assessed using Hoffmann reflex (H-reflex). Both the AAS and control groups have completed H-reflex tests of the soleus, fibularis longus, and tibialis anterior that were performed bilaterally in the quiet, bipedal stance. Maximum peak-to-peak amplitudes of H-reflexes (H-max) and motor waves (M-max) were recorded. **Main Outcome Measures:** The H-max was normalized to M-max to obtain Hmax:Mmax ratio for each muscle since H-max significantly varies between individuals. Separate two-way ANOVAs with repeated measures were performed to compare groups (AAS, control) and limbs (injured, uninjured) for each of the muscles. The alpha level was set at <.05. **Results:** There were no significant group-by-limb interactions for all muscles: the soleus ($F_{(1,35)}$ = .663, P = .42), fibularis longus ($F_{(1,34)}$ = .486, P = .49) and tibialis anterior ($F_{(1,25)}$ = .546, P = .47). However, there was a significant group main effect for the soleus ($F_{(1,35)}$ = 6.612, P = .015). The Hmax:Mmax ratio in the AAS group (.38 ± .04) was significantly lower than in the healthy control group (.53 ± .04). No significant main effects were found in the fibularis longus ($F_{(1,34)}$ = .009, P = .93) and tibialis anterior ($F_{(1,25)}$ = 2.226, P = .15). **Conclusions:** Decreased spinal excitability in the soleus, as determined by Hmax:Mmax ratio, was present bilaterally in patients with AAS. This result indicates that bilateral arthrogenic muscle inhibition may explain bilateral muscle dysfunction following the unilateral acute injury.

Reliability & Responsiveness of Sensory-Reweighting Strategies in Those With Chronic Ankle Instability

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Context: Chronic ankle instability (CAI) patients have known balance impairments and research suggests these CAI associated balance impairments might be due to an inability to appropriately reweight sensory and/or somatosensory information. CAI patients place a greater emphasis on visual information while balancing than uninjured controls. However, the reliability and responsiveness of sensory reweighting outcomes in CAI patients has yet to be established. **Objective:** To evaluate the reliability and responsiveness of sensory reweighting strategies captured during single limb stance in CAI patients. **Design:** Reliability Study. **Setting:** Research Laboratories. **Patients or Other Participants:** 77 patients with self-reported CAI (31 males, 46 females; age: 22.8 ± 4.5 yrs; height: 171.3 ± 9.5 cm; mass: 74.6 ± 16.1 kg) participated. CAI was defined as at least two episodes of "giving way" within the past 3 months; scoring <90% on the Foot and Ankle Ability Measure (FAAM), and scoring <80% on the FAAM-Sport. **Interventions:** All patients performed 3, 10-second trials of eyes open and eyes closed single-limb stance on a force plate standing on the self-reported higher-functioning limb. After baseline testing, patients were instructed to maintain normal daily activities for 2-weeks before being reassessed using the same single-limb balance assessment protocol. **Main Outcome Measures:** To capture postural control behavior, the COP velocity (COP-V) and the mean time-to-boundary (TTB) were calculated for both the AP and ML

directions with eyes open and closed. The % change in postural control performance due to sensory-reweighting without vision was calculated by subtracting the eyes open mean from the eyes closed mean and dividing the difference by the eyes open mean for each variable. The larger the % change in the sensory-reweighting ratio, the greater the reliance on visual information. Reliability estimates were calculated using ICC(1,3). To determine responsiveness, the standard error of the measure (SEM) was calculated for each variable from the reliability estimates. **Results:** The % change of sensory-reweighting for COP-V demonstrated fair reliability with relatively high measurement error for both ML and AP directions. (MLCOP-V ICC(1,3) = 0.67, SEM = 26%; APCOP-V ICC(1,3) = 0.72, SEM = 30%). The % change in sensory-reweighting for TTB also demonstrated fair reliability with relatively low measurement error in both directions (ML-TTB ICC(1,3) = 0.61, SEM = 9%; AP-TTB ICC(1,3) = 0.65, SEM = 7%). **Conclusions:** The reliability and responsiveness of % change in sensory-reweighting in both the ML and AP directions were consistently fair among COP-V and TTB outcomes. Based on the results, a shift of approximately 30% of the sensory-reweighting ratio would be needed to indicate a change outside normal measurement error whereas a shift of around 9% in the TTB ratio would be needed. Our findings suggest that sensory organization strategies, specifically the sensory-reweighting ratio generated from the mean of TTB, would be a viable outcome to assess following therapeutic interventions given the fair reliability and low responsiveness values.

Non-Linear Analysis of Postural Stability Under Dual-Task Conditions in Patients With Chronic Ankle Instability, Copers, and Controls

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Context: Chronic ankle instability (CAI) is a consequence of ankle injury and causes significant disability and pain. Patients with CAI are often assessed using static single-leg balance tasks, but this may not capture changes in postural stability that occur under divided attention tasks ("dual-task"). In addition, linear center of pressure measurements (sway, velocity) may fail to find changes that indicate underlying pathology. **Objective:** To compare postural stability in patients with CAI to copers and controls during dual-task conditions, using non-linear methods. **Design:** Case-control. **Setting:** Biomechanics Laboratory. **Patients or Other Participants:** Forty-five participants were divided into three groups: healthy controls without history of ankle injury (n = 15 (9F, 6M), 22.7 ± 2.3 years, 171.3 ± 10.3 cm, 74.9 ± 12.7 kg, Cumberland Ankle Instability Tool (CAIT) = 29.9 ± 0.35), copers with history of ankle injury but no reported instability (n = 15 (9F, 6M), 22.1 ± 2.3 years, 172.5 ± 10.4 cm, 71.1 ± 10.4 kg, CAIT = 28.4 ± 1.1), and participants with CAI (n = 15 (9F, 6M), 22.7 ± 3.4 years, 169.9 ± 8.4 cm, 70.2 ± 15.4 kg, CAIT = 17.5 ± 5.7). **Interventions:** All participants performed a single-leg balance test on a force platform for 60sec under a control (CON) condition, and two dual-task conditions: dichotic listening (DiL), and serial-subtraction calculation (CAL). The leg assessed was determined as: CAI (leg with CAI or the lowest CAIT score if CAI was bilateral), coper (leg with the most reported prior ankle injuries), and control (leg matched to CAI group). Center of pressure (CoP) excursion in the anterior-posterior (AP) and medial-lateral (ML) directions was collected at 1000Hz. **Main Outcome Measures:** Sample entropy (SampEn) was calculated from CoP data. SampEn is a non-linear method of analyzing regularity in a time series. Lower values indicate greater regularity or pattern repetition, while higher values indicate less regularity and more randomness. 3x3 mixed-model ANOVAs (group x task) were performed on SampEnAP and SampEnML ($p < 0.05$), with post-hoc Bonferroni-corrected comparisons on significant results. **Results:** There was a significant main effect for task for SampEnAP ($F_{2,84} = 5.28$, $p = 0.007$). SampEn for CON (0.59 ± 0.11) was significantly higher compared to CAL (0.54 ± .13) ($p = 0.011$), but not different from DiL (0.56 ± 0.10) ($p = 0.146$). There were no significant differences between groups in SampEnAP ($F_{2,42} = 0.62$, $p = 0.543$), and no significant differences between groups or tasks for SampEnML ($F_{4,84} = 2.33$, $p = 0.063$). **Conclusions:** Patients with CAI do not display differences in regularity of postural stability, even when attention is divided. However, certain cognitively-demanding tasks (such as serial subtraction) do increase the regularity of anterior-posterior CoP motion. This suggests a change in motor control strategy to constrain the systems responsible for postural stability during more challenging tasks. This increase in regularity may compromise the ability to respond to unexpected challenges and lead to loss of balance. In biological systems, changes in SampEn values are associated with pathology or aging. Researchers should further examine whether changing the complexity of static stability measures improves balance and function in healthy and injured populations.

Sensory Organization Testing in Individuals With Chronic Ankle Instability

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Context: Individuals with chronic ankle instability (CAI) have known balance impairments. Recent research suggests these CAI associated balance impairments might be due to an inability to appropriately reweight sensory and/or somatosensory information. More specifically, individuals with CAI appear to place a greater emphasis on visual information while balancing than uninjured controls during single limb stance when measured using time-to-boundary. However, the further research is needed to determine if altered sensory organization strategies persist in CAI patients while balancing. **Objective:** To quantify and differentiate the acuity of the three sensory feedback systems (somatosensory, visual, and vestibular) in balance control. **Design:** Cross-sectional study. **Setting:** Research laboratory. **Patients or Other Participants:** 20 CAI patients (7 M, 13 F; 20.3 ± 0.98 yrs; 171.58 ± 13.20 cm; 71.89 ± 14.89 kg) and 20 healthy individuals (3 M, 17 F; 20.25 ± 0.72 yrs; 167.26 ± 9.69 cm; 62.07 ± 8.56 kg). CAI was defined as history of at least one ankle sprain, at least 2 giving way episodes in past six months, and scoring ≥ 11 on IdFAI, ≤90% on FAAM and ≤80% on FAAM-S. **Interventions:** All participants completed the sensory organization test (SOT) in a double and single limb stance using the NeuroCom SMART EquiTest® system. All participants were asked to stand as still as possible during six conditions of the SOT: 1) eyes open (EO) with fixed surface (FS) and fixed visual surround (FVS), 2) eyes closed (EC) with FS, 3) EO with sway-referenced visual surround (SRVS) and FS, 4) EO with sway-referenced support surface (SRSS) and FVS, 5) EC with SRSS, 6) EO with SRSS and SRVS. Each condition was tested with three, 20-s trials. **Main Outcome Measures:** An overall composite equilibrium score (COMP), scores for the somatosensory (SOM), visual (VIS), and vestibular (VEST) systems. Separate Independent sample t-tests were used to compare the CAI and control groups for each score with $\alpha = 0.05$. **Results:** For double limb stance, COMP (CAI: 73.05 ± 5.18, Control: 67.15 ± 9.91, $p = 0.014$) and VEST (CAI: 77.65 ± 6.13, Control: 73.55 ± 6.39, $p = 0.020$) scores were significant lower in CAI group. No differences in SOM (CAI: 96.60 ± 3.33, Control: 96.50 ± 2.37, $p = 0.914$) or VIS (CAI: 85.40 ± 5.21, Control: 87.85 ± 8.0, $p = 0.258$) were noted. For single limb stance, COMP scores ($p = 0.039$) were significant lower in CAI group (70.20 ± 3.91) relative to the control group (73.00 ± 4.38). SOM (CAI: 81.95 ± 9.59, Control: 85.20 ± 5.00, $p = 0.187$), VIS (CAI: 91.15 ± 5.95, Control: 90.35 ± 6.39, $p = 0.684$), and VEST (CAI: 62.95 ± 8.48, Control: 64.70 ± 10.54, $p = 0.566$) did not differ between the groups. **Conclusions:** Individuals with CAI exhibited postural control deficits compared to healthy individuals in both double and single limb stance. However, the current results suggest that sensory organization strategies, as measured by the SOT, do not differ between CAI patients and uninjured controls. Further research is needed to correlate sensory organizational strategies with sensory input function (e.g. visual acuity) and to assess sensory organization strategies during more dynamic tasks in those with CAI.

The Association of Corticospinal Excitability and Inhibition With Ankle Kinematics in Chronic Ankle Instability Individuals

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Context: Reorganization of the sensorimotor system has been hypothesized as one possible mechanism for CAI development in many individuals following a lateral ankle sprain(LAS) and a lack thereof in LAS-Copers. Particularly, researchers have noted depression in corticospinal excitability of the surrounding ankle musculature in those with CAI compared to uninjured controls. Changes within the descending corticospinal tracts likely influence feedforward neuromuscular control at the ankle joint in those with CAI. These potential impairments are believed to predispose individuals to recurrent joint injury during dynamic tasks. However, there has yet to be any direct links established between changes within the descending corticospinal tracts and movement patterns in those with CAI. By establishing these connections, we can begin to understand the impact of underlying neurophysiological changes on movement patterns in those with and without CAI. **Objective:** Compare differences in corticospinal excitability and inhibition of the Tibialis Anterior(TA) muscle and pre-landing sagittal-plane ankle kinematics between groups, and examine the association between variables within each group. **Design:** Single-blinded Case Control Study. **Setting:** Research Laboratory. **Patients or Other Participants:** Thirteen participants with 24.76 ± 4.14 years, 168.62 ± 9.09 cm, 76.48 ± 16.28 kg) and 12 LAS-Copers (25.00 ± 6.1 years,161.13 ± 6.89 cm, 59.58 ± 8.16 kg) volunteered. **Interventions:** Participants performed 5 vertical jumps (50% of maximum) with single-leg landings. Kinematics were collected with 10 high-speed cameras, 56

retro-reflective markers and 3D motion analysis software. Transcranial Magnetic Stimulation (TMS) assessed corticospinal excitability and inhibition of the TA muscle. **Main Outcome Measures:** Sagittal-plane ankle kinematics were captured at four time points prior to landing (200ms,150ms,100ms,50ms) and at initial ground contact (IGC). Eight stimuli delivered at 120% of active motor threshold assessed corticospinal excitability and inhibition of the TA muscle. Corticospinal excitability was assessed by averaging motor evoked potential (MEP) amplitude and normalizing it to the resting baseline EMG signal. Corticospinal inhibition was quantified using the Cortical Silent Period (CSP), determined by distance from the end of the MEP to a return in mean EMG activity plus 2 standard deviations above baseline EMG signal. The ratio of MEP and CSP at 120% (MEP:CSP) was calculated to represent the coordinated balance between corticospinal excitability and inhibition. Separate Mann-Whitney U tests were used to assess for group differences. Spearman's Rank Correlations assessed associations of kinematics with corticospinal excitability and inhibition measurements for each group. **Results:** No between-group differences were detected for any corticospinal measure or ankle kinematics ($P > 0.05$). Within the CAI group only, the MEP:CSP ratio was negatively correlated with ankle kinematics at 200 ms ($p = 0.007, \rho = -0.665$), 150 ms ($p = 0.023$, $\rho = -0.560$), 100 ms ($p = 0.035$, $\rho = -0.516$), and 50 ms ($p = 0.027$, $\rho = -0.544$) pre-landing and at IGC ($p = 0.029$, $\rho = -0.538$). **Conclusions:** The negative correlation observed in those with CAI indicates the greater coordination between cortical excitability and inhibition may lead to increased dorsiflexion range of motion during a jump-landing task; providing an insight to the possible neurophysiological mechanisms increasing the risk of recurrent joint injury and dynamic joint stability during dynamical tasks in those with CAI.

Visual and Neurocognitive Function in Individuals With Chronic Ankle Instability

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Context: Chronic ankle instability (CAI) occurs from repetitive lateral ankle sprains and results in self-reported "giving way. This effect is associated with altered brain regulation of muscle tone and mechanical stability. These nervous system changes may represent deficits in motor planning and cognition. However, evidence to support neurocognitive changes following ankle sprains is inconclusive. **Objective:** To determine if individuals with CAI display functional neurocognitive deficits. **Design:** Cross-sectional. **Setting:** Research laboratory. **Patients or Other Participants:** Fifty participants (12 female, 16 CAI, 20.16 ± 1.62 years, 1.77 ± 0.09 m, 79.19 ± 11.53 kg) were assigned to the control or CAI group based on self-Identification of Functional Ankle Instability (IdFAI). Scoring 0 on the IdFAI and never sustaining an ankle injury placed participants in the control group. The CAI group was identified by scoring greater than 11 with no ankle injury within 3 months (IdFAI: CAI: 18.5 ± 4.18, CON: 0 ± 0). **Interventions:** Participants completed the y-balance test in three directions, anteromedial, posteromedial and posterolateral. The average of three trials for each direction, normalized to the participant's leg length was used to calculate the composite reach (sum of normalized distances). A Bertec vision trainer (Bertec Inc, Columbus, OH) was used to assess central and peripheral reaction time, visual memory, and target acquisition. The average of five trials for reaction time and targets and three trials for memory were used in analysis. **Main Outcome Measures:** Dependent variables were reaction time (seconds to respond), memory (number correct in sequence), and targets (responses in 30 seconds). The independent variables were group (CAI and control). A one-way repeated measures MANOVA was conducted for all dependent variables. Alpha level was set a priori at $p < .05$. **Results:** A power analysis was conducted to determine sample size. Based on published effect sizes for the y-balance test (0.8), alpha 0.05, power 0.95, two groups, four measures, and a correlation among measures of 0.5, the sample size needed per group was 15. There were no between-group differences on any neurocognitive, visual-motor variable, or functional performance measure (reaction time central: CAI: 0.32 ± 0.05, CON: 0.35 ± 0.07; reaction time peripheral: CAI: 0.54 ± 0.09, CON: 0.47 ± 0.07; central memory: CAI: 7.12 ± 2.01, CON: 8.12 ± 3.14; peripheral memory: CAI: 6.68 ± 1.99, CON: 7.40 ± 2.24; targets: CAI: 28.44 ± 1.89, CON: 27.76 ± 2.11; reach composite sum: CAI:2.66 ± 0.19, CON: 2.70 ± 0.22) **Conclusions:** Neurocognitive and visual motor function were not impaired in this cohort of high functioning CAI individuals. Of particular note is the lack of reach distance differences that have been well documented in the literature for the CAI cohort. It is possible that this group was able to compensate for CAI with improved dynamic stability (reach distance), thus while the IdFAI indicated a state of ankle instability, this may not translate to functional deficits. CAI may not cause sufficient insult to the nervous system to induce adaptations in neurocognitive or visual-motor function.

Cortical Activity Relates to Injury Severity in Chronic Ankle Instability Patients

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Context: Sensorimotor deficits are well documented in patients with chronic ankle instability (CAI), including altered feed-forward and feed-back control outcomes as evidenced by gait initiation and static balance impairments, respectively. Recent evidence has shown altered function of the motor cortex in CAI patients; however, this was collected in a non-weight bearing position. It is currently unclear if such motor cortex alterations would also be present in CAI patients during weight-bearing movements. **Objective:** To determine if a relation exists between feed-forward cortical activity, patient-reported outcomes, and injury demographics in CAI patients during a weight-bearing task. **Design:** Observational cohort. **Setting:** Research laboratory. **Patients or Other Participants:** Ten patients with self-reported CAI (age: 21.30 ± 2.41 years; height: 165.69 ± 23.74 cm; mass: 81.55 ± 41.55 kg) participated. CAI was defined as a history of at least one lateral ankle sprain (2.80 ± 2.04), ≥2 episodes of "giving way" within the past 6 months (4.70 ± 3.59), and scoring >11 on the Identification of Functional Ankle Instability (IdFAI) instrument (17.90 ± 2.77). **Interventions:** Participants completed 120 trials of voluntary leaning in three directions (anterior, medial-lateral to the involved limb, medial-lateral to the uninvolved limb) while electroencephalographic (EEG) data were recorded. Force platform data were used to identify the onset of movement. **Main Outcome Measures:** The magnitude of motor-related cortical potentials (MRCP) was extracted from the EEG data at movement onset. A more negative magnitude of the MRCP indicates more cortical resources are required for motor control (i.e. less automatic). Patient-reported outcomes included the IdFAI, the Foot and Ankle Ability Measure scales, and injury demographics such as the total number of sprains and the number of episodes of "giving way" in the past 6 months. A repeated-measures ANOVA was used to identify differences in MRCP among movement directions. Dependent variables were correlated using Pearson product moment correlations. Alpha was set at 0.10 for all analyses. **Results:** The MRCP was significantly larger when leaning towards the involved limb (-16.86 ± 8.57 μV) than leaning anteriorly (-13.23 ± 4.89 μV; $p = 0.060$). No pairwise differences were observed when leaning towards the uninvolved limb (-15.29±6.06μV). Strong positive correlations were identified among all three leaning directions ($r > 0.795$). A moderate positive correlation was identified between the number of "giving way" episodes and MRCP leaning towards the involved ($r = 0.549$) and uninvolved ($r = 0.583$) limbs. **Conclusions:** Strong positive correlations among all three directions may suggest that there is a global change in the function of the motor cortex. The relationship between giving way episodes and cortical activity during a weight-bearing task in these patients may indicate that there is an increase in cortical control of movement in CAI patients with more instability. An increase in cortical control is representative of a less automatic sensorimotor system which may cause interference during multi-task (e.g. sporting) situations.

Neurocognitive Function is Related to Perceived Disability in Individuals With Chronic Ankle Instability

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Context: Chronic ankle instability (CAI) is a potential consequence of lateral ankle injury, and patients display characteristic patterns of mechanical and perceived instability. Recently, researchers have found alterations in the sensorimotor system that contribute to the impairments observed in patients with CAI. These results suggest a complex interaction between the central nervous system and the function of the ankle joint. The feeling of "giving way" and uncontrolled instability during dynamic movement in those with CAI may be perpetuated by deficits in neurocognitive function, such as impaired attention, reaction time or visual processing. However, it remains unclear if neurocognitive function plays a role in perceived CAI function. **Objective:** To identify the relationship between neurocognitive function and self-reported disability in those with CAI. **Design:** Cross-sectional **Setting:** Biomechanics Laboratory **Patients or Other Participants:** 15 individuals (6 male, 9 female: age = 22.9 ± 3.4 years, height = 169.9 ± 8.4 cm, mass = 70.8 ± 15.8 kg) with CAI who reported a history of moderate to severe ankle sprain and two or more episodes of "giving way" in the previous 12 months. **Interventions:** Participants completed the Cumberland Ankle Instability Tool (CAIT) and CNS Vital Signs (CNSVS) on a laptop computer. The CNSVS is a battery of valid and reliable computer-based neurocognitive tests. It consists of multiple individual components including the Verbal Memory, Visual Memory, Finger Tapping, Symbol Digit Coding, Stroop, Shifting Attention, Continuous Performance Tests and

the Pain Catastrophizing Scale (PCS) used to assess neurocognitive abilities. **Main Outcome Measures:** Variables assessed from the CNS vital signs included an overall neurocognitive index (NCI) as well as standardized individual domains of composite memory, verbal memory, psychomotor speed, reaction time, complex attention, cognitive flexibility, processing speed, executive function, simple attention, motor speed, and the PCS with its sub-scales (rumination, magnification and helplessness). The relationship between the CAIT and the CNSVS domain scores were assessed via Pearson's correlational coefficients ($p \leq .05$). **Results:** The CAIT (17.5 ± 5.6) was significantly correlated with the NCI (102.9 ± 6.6, $r = 0.44$, $p = .05$), Visual Memory (108.1 ± 13.0, $r = 0.43$, $p = .05$), Reaction Time (101.9 ± 9.4, $r = 0.48$, $p = .04$), and the Magnification subscale of the PCS (1.5 ± 1.5, $r = -0.47$, $p = .04$). **Conclusions:** Neurocognitive function may facilitate perceived disability in individuals with CAI as indicated by moderate correlational coefficients. Those who reported higher levels of perceived ankle function demonstrated greater levels of overall neurocognitive function, visual memory and reaction time. Additionally, those who reported more severe levels of self-reported disability indicated higher pain magnification, possibly associated to how individuals with CAI perceive their discomfort. Clinically, targeting neurocognitive deficits may be necessary to improve rehabilitation outcomes in those with CAI. Future research is necessary to explore neurocognition and to determine if neurocognitive training will result in greater joint stability in patients with CAI.

Free Communications, Rapid Fire Oral Presentations: Concussion Outcomes: The Acute Stage

Wednesday, June 28, 2017, 10:15AM-11:15AM, Room 371; Moderator: David Howell, PhD, ATC

Post-Concussion Symptom Reporting: Is Gender A Factor in the Adolescent Population?

Dunne JA, Feng D, Girouard TJ, Landers MR, Freedman Silvernail J, Radzak KN: University of Nevada, Las Vegas, NV

Context: Despite previous meta-analyses evaluating gender differences in symptom reporting, results are not specific for the adolescent population. Adolescent sport participation and concussion incidence rates are increasing. Therefore, clarity of gender specific symptom presentation in adolescent athletes is needed. **Objective:** The current meta-analysis and systematic review is intended to evaluate the literature and determine if differences exists in post-concussion symptom reporting between male and female adolescent athletes. We hypothesized that significant gender differences in the percentage of the adolescent population reporting common post-concussive symptoms would be present. **Data Sources:** PubMed, SPORT Discus, Cochrane Library and Web of Knowledge databases, ProQuest database, and Google Scholar were utilized. Database search terms consisted of: Concussion AND Adolescent AND Symptoms. Limitations consisted of: human research, written in English, included children (6-12) and adolescents (13-18), published between 1993 and February, 2016. Google Scholar search terms were restricted to title only. **Study Selection:** The current systematic review and meta-analysis adhered to PRISMA guidelines and reporting criteria. Full-length publications or unpublished thesis/dissertations, utilizing adolescent athletes, of either or both genders, who sustained a concussion and reported post-concussion symptoms, either self-reported or using neurocognitive testing, were included. Symptoms reported were divided by gender. Symptom data collection was required to be performed within one-month post-concussion. **Data Extraction:** Removing duplicates, 2,492 abstracts were reviewed for inclusion criteria; 2,171 articles were excluded. The remaining 321 articles were reviewed in full-text, 318 additional articles were excluded. Three studies were ultimately included in the systematic review and meta-analysis. Once the inclusion criteria was met and deemed appropriate by two researchers, using the Newcastle Ottawa Scale, data was extracted from the remaining primary studies. Variables extracted included total number of participants within the study, number of males, number of females, specific symptoms reported by study participants and gender specific incidence of symptom reporting. **Data Synthesis:** Using Microsoft Excel, data were extracted and separated by gender. Weighted proportion of symptoms reported between males and females was calculated. Z-scores were calculated to evaluate gender differences in symptoms reported; all tests were two-tailed and significance was set at $p < 0.05$. A significantly greater percentage of concussed female adolescent athletes reported concentration difficulty (M = 47%, F = 55%; $p = 0.005$), drowsiness (M = 21%, F = 34%; $p < 0.001$), sensitive to light/visual disturbance (M = 32%, F = 38%; $p = 0.017$) and sensitivity to noise (M = 12%, F = 23%; $p < 0.001$) compared to male adolescent athletes. Male adolescent athletes had a significantly greater percentage of concussed athletes who reported amnesia (M = 21%, F = 14%; $p < 0.001$) and irritability (M = 81%, F = 12%; $p = 0.031$). **Conclusions:** The current meta-analysis and systematic review provides evidence that adolescent gender differences are present in reporting certain post-concussion symptoms. Future adolescent specific population research should continue to evaluate how adolescent athletes respond to a concussive injury and the influence gender plays in athletes' symptom reporting.

Examination of Anxiety and Willingness to Return to Play in Injured Athletes

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Context: Athletes sustain concussions (SRC) as well as other non-season ending injuries (NSEIs) including muscle strains and ligament sprains. In both conditions athletes have reported similar psychological effects due to their injury. Unlike concussions there are visible signs of NSEIs including swelling and ecchymosis. Psychological effects such as anxiety can affect athletes' willingness to return to play (RTP). **Objective:** The purpose of this study was to determine if there is a difference in the psychological effects of injury experienced by those who sustain sports related concussions (SRC) versus other non season ending injuries (NSEI). **Design:** Retrospective Cohort. **Setting:** Online survey. **Patients or Other Participants:** Division I (n = 52), II (n = 6) and III (n = 3) collegiate student athletes completed an online survey. **Interventions:** The online survey collected information on the athlete's level of play, sport, specific injury, time lost, General Anxiety Disorder 7-item scale, Injury-Psychological Readiness to Return to Sport scale (I-PRRPS), number of symptoms experience and number of treatments received. The GAD-7 score measured athletes' level of anxiety at time of injury, and the I-PRRPS measured the athletes' willingness to RTP after injury. **Main Outcome Measures:** Dependent variables of interest were GAD-7 score and I-PRRPS score. GAD-7 statements were graded on a scale of not at all (0) to nearly every day (3) based on feelings about each statement. A sum of all scores was taken; overall scores <5 = mild anxiety, scores 6-14 = moderate anxiety, and scores of ≥15 = severe anxiety. In the I-PRRPS 6 statements were scored 0 (no confidence)-100 (utmost confidence). The score of each statement was summed

and divided by 10. A max score of 60 = utmost confidence a score of 40 = moderate confidence, and a score of ≤ 20 = low overall confidence. The independent variable was group (Concussion vs. NSEIs). **Results:** A one-way ANOVA analysis compared GAD-7 scores and I-PRRPS scores by group ($p>.05$). We found no differences in GAD-7 or I-PRRPS. Pearson correlation revealed a weak positive correlation ($p < .05$) between level of anxiety experienced and number of symptoms from injury reported. **Conclusions:** We hypothesized that those who sustained concussions would have less anxiety and more willingness to return to play than those who sustained other NSEI's as they were not able to visualize the signs of injury that are typically seen in a NSEI. Our findings could be in part due to increased education and awareness of SRC in competitive athletes due to the efforts of their athletic trainers. Thus suggesting that athletes who experience SRC treat their injury as they do other NSEI even when signs and symptoms are not physically present. Increased education in treatment of any injury is a key in keeping athletes safe in all future competitions.

Adolescent Athletes' Perceptions of Activity Limitations Following Sport-Related Concussion

Valovich McLeod TC, Johnson RS, Williams RM, Valier AR: A.T. Still University, Mesa, AZ

Context: Concussion assessment has begun to include broader evaluations of health-related quality of life through evaluation of patient-reported outcome measures (PROMs). However, unlike other orthopedic injuries, there is not a condition specific PROM designed purposefully to evaluate the patient's perspective of health limitations following sport-related concussion. **Objective:** To explore patient-perceived activity limitations following concussion and throughout return-to-play (RTP). **Design:** Longitudinal. **Setting:** Secondary school athletic training facilities. **Patients or Other Participants:** Fifty patients (41 males, 5 females, 4 missing, age = 14.9 ± 3.5 years, grade = 10.2 ± 0.93 level) with a medically diagnosed sport-related concussion. **Interventions:** The Patient Specific Functional Scale (PSFS) was used to assess changes in a patient's condition and the impact the injury posed on the patients' ability to achieve desired activities. The PSFS was administered to patients on days 3 (D3) and 10 (D10) following concussion and at RTP. The PSFS is a self-reported scale that asks patients to identify 3-5 activities that are impacted by the injury and instructs patients to rate the difficulty of performing those tasks on a scale of 0 (unable to perform) to 10 (no difficulty). Activities were coded into common themes by a three-person research team for subsequent analysis. **Main Outcome Measures:** The dependent variables were the PSFS themes, number of activities endorsed, and PSFS scores. Descriptive analyses and frequencies were reported for the dependent variables. **Results:** Six themes were identified: activities of daily living (ADLs), cognitive and school (COG), sports and physical activity (SPA), screen time (SCR), sleep (SLP) and social (SOC). On D3, all patients (50/50) identified an activity limitation. A total of 157 activities were identified with the majority related to SPA (37.6%, 59/157), followed by COG (31.2%, 49/157), ADL (15.9%, 25/157), SCR (11.5%, 18/157), SLP (3.8%, 6/157), and no SOC endorsements. The mean D3 PSFS score was 5.0 ± 2.7. Sixty percent of patients endorsed activity limitations at D10. A total of 101 activities were identified with the majority coded as COG (38.6%, 39/101) and SPA (36.6%, 37/101), followed by ADL (14.9%, 15/101), SCR (5.0%, 5/101), SLP (3.0%, 3/101), and SOC (2.0%, 2/101). The mean D10 PSFS score was 6.6 ± 3.7. At RTP, patients reflected on prior activity limitations and PSFS scores improved to 9.0 ± 2.6. **Conclusions:** Following concussion, adolescent athletes identified activity restrictions that impacted their perceived health status, primarily related to physical activity and sports participation. Of note is that many patients identified activity limitations related to school, reading, screen time and activities of daily living. Although physical and cognitive rest may be beneficial immediately post-concussion, symptom-limited resumption of light physical and cognitive activities, may be warranted to aid recovery and patient perceived health status. Future research into the development of a concussion-specific PROM that captures patient perspective of broad domains of health is needed.

The Use of Academic Adjustments Following Concussion Among Adolescent Athletes

Welch Bacon CE, Williams RM, Johnson RS, Valovich McLeod TC: A.T. Still University, Mesa, AZ

Context: The recommended course of action immediately post-concussion is physical and cognitive rest. For adolescent athletes, rest may include missed school days or implementation of academic adjustments (AA) to assist with the return-to-school progression. Little is known whether these recommendations are being incorporated as part of the immediate post-concussion management plan. **Objective:** To characterize concussion management practices specific to AA for adolescents post-concussion. **Design:** Longitudinal. **Setting:** Secondary school athletic training facilities. **Patients or Other Participants:** 318 student-athletes (223 males, 30 females, 65 missing; age = 12.1 ± 8.12) who were medically diagnosed with a concussion between 2010-2015. **Interventions:** As part of a larger study, participants completed a general academic survey administered at Days 3 (D3) and 10 (D10) post-concussion. The survey included items that addressed school absence, types of AA received, and perceived changes in academic performance. **Main Outcome Measures:** The independent variables included concussion history (yes, no) and sex (male, female). Dependent variables included school absence, AA received, types of AA, and changes in academic performance. Descriptive statistics were calculated to report overall findings. Chi-Square tests ($P < .05$) were used to identify group differences. **Results:** Of 279 patients that completed the general academic survey D3 post-concussion, 23.6% (n = 75/279) reported missing school days following injury. Only 17.3% (n = 55/277) of patients reported receiving AA by D3. While 55 patients received at least one type of AA at D3, only 27.3% (n = 15/55) reported receiving two types of AA, and only 7.2% (4/55) received three. The most common AA were extra time for assignments (54.5%, n = 30/55), rest breaks (12.7%, n = 7/55), or special permission to leave class (12.7%, n = 7/55). 66% of patients (n = 70/106) reported changes to school performance at D3. Of those 70 patients, 43 patients (61%) reported changes but did not receive AA, 24 (34.3%) reported changes and did receive AA, and 3 (4.3%) received AA but did not report changes in performance. There were no differences between patients with or without a concussion history and school days missed (P = 0.64), provision of AA (P = 0.81), or changes in school performance by D3 (P = 0.89). There were no differences between the sexes regarding school days missed (P = 0.78) or AA received (P = 0.61) by D3. Males reported more changes in academic performance than females by D3 (P = 0.028). Of 251 patients that completed the D10 survey, 44 patients (13.8%) reported receiving AA by D10. 54.5% of those patients (n = 24/44) also received AA at D3, while 29.5% (n = 13/44) did not. **Conclusions:** These findings provide an initial description of AA for concussed adolescents in the secondary school setting. Only a small percentage of patients received AA following a concussion, while more patients reported changes in school performance, suggesting a need for better communication between patients and providers to assist the return-to-school process.

Concussion Education Associated With Teachers' Increased Familiarity With and Recommendation of Academic Adjustments for Adolescents Post-Concussion

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Context: Deficits post-concussion can affect a student's academic performance; therefore, academic adjustments (AA) may be warranted to prevent falling behind in coursework. Teachers play an important role in an adolescent's return-to-learn post-concussion; however, little is known about teachers' perceptions of AA as part of the management of concussion. **Objective:** To examine teachers' perceptions of and experiences with implementing AA post-concussion. **Design:** Cross-sectional. **Setting:** Self-reported online survey. **Patients or Other Participants:** Of the 5,754 emails sent to teachers, 426 accessed the survey (7.4% response rate) and 334 teachers (128 male, 197 female, 9 missing; years of experience = 15.5 ± 10.9 years; across 45 states) completed the survey (78.4% completion rate). There were 141 teachers with formal concussion education (TeachwEd), 185 teachers without formal education (TeachwoEd), and 8 missing. **Interventions:** Teachers were emailed to request their completion of the Beliefs, Attitudes, and Knowledge of Pediatric Athletes with Concussion (BAKPAC) survey. The BAKPAC is a previously validated instrument that contains several 4- and 6-point Likert scale and closed-ended items on perceptions of concussion and AA. A separate version was tailored to teachers (BAKPAC-TEACH), piloted, and minor adjustments for clarity were made prior to dissemination. **Main Outcome Measures:** Descriptive statistics were calculated to describe teachers' perceptions and experiences with AA. Mann Whitney U and Chi-Square tests ($P < .05$)

were used to describe group differences. Dependent variables were participants' responses; total responses varied for each item. **Results:** Overall, teachers strongly agreed (Mdn = 4.0/4.0, M = 3.75/4.0 ± 0.48) that concussions could affect school performance and 71.6% (234/327) had a student who received AA post-concussion. Regarding AA implementation, only 27.3% (90/330) of teachers reported that an academic team was established. More TeachwEd reported having an established team (59.8%, 52/87) than TeachwoEd (40.2%, 35/87), and more TeachwoEd were unsure if a team existed (68.2%, 103/151) (X22 = 18.273, N = 325, P < .001). TeachwEd were moderately familiar with AA (Mdn = 3.0/4.0, M = 2.9/4.0 ± .8, P = .023) and almost always recommended AA (Mdn = 2.0/6.0, M = 3.0/6.0 ± 1.8, P=.045); whereas, TeachwoEd were moderately familiar with AA (Mdn = 3.0/4.0, M = 2.7/4.0 ± .9) and sometimes recommended AA (Mdn = 3.0/6.0, M = 3.5/6.0 ± 1.9). If concerned about a student's academics, teachers would more likely consult with the school nurse (59.3%, 198/334) and school counselor (53.6%, 179/334) than the athletic trainer (33.2%, 111/334). **Conclusions:** Teachers recognize that concussions affect academic performance, and many have provided AA within their classrooms. Participation in formalized concussion education was associated with increased familiarity with AA and increased frequency of recommending AA for adolescents post-concussion. Although monitoring AA should not be the primary responsibility of the athletic trainer, involvement in the delivery of concussion education and development of an academic support team may aid in providing whole-person care for student-athletes after concussion.

High School Principals' Perception of Concussion and Return to Learning Accommodations

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Context: Studies in adolescents show increased symptom reporting when prescribed strict or prolonged cognitive rest following a concussion, suggesting it is beneficial to gradually return to the learning environment. High school principals are valuable to concussion management and influence academic accommodations. Their perceptions of concussion management dictate the level of care and accommodations students will receive when returning to learning. **Objective:** To assess high school principals' perceptions of concussions and allowing academic accommodations. **Design:** Cross-sectional study. **Setting:** Online survey. **Patients or Other Participants:** 157 Indiana public high school principals; response rate of 38% (157/410). **Interventions:** Participants were recruited through the Indiana Department of Education and solicited via email to complete a 10 question anonymous survey. **Main Outcome Measures:** The survey was divided into two sections. Questions 1, 5, and 6 assess high school principals awareness of concussion prevalence and 2, 3, 4, 7, 8, 9, and 10 assess principal's awareness of possible concussion interventions. Descriptive statistics were utilized to summarize the responses. **Results:** 42% (65/155) of principals reported 1 to 5 students suffered a concussion in the last year. 34% (50/149) received training in the academic management of students with concussion. 95% (141/149) of principals had access to a school nurse or an individual comfortable monitoring a student experiencing concussion related symptoms. 84% (123/147) expressed being either very comfortable or somewhat comfortable managing students with concussions, whereas 17% (24/147) expressed discomfort or do not manage concussed students. The majority of principals (75/144; 52%) state lack of communication among students, physicians, and schools as the largest barrier when instituting academic accommodations. 92% (133/145) state willingness to accept academic accommodations as long as necessary. Principals were highly likely or likely to allow students to take frequent breaks (132/138; 96%), limit screen time (138/140; 99%), test or work in a quiet environment (139/140; 99%), and avoid busy environments (134/139; 96%). Accommodations for testing depended on the type of testing: 71% (95/134) of principals reported that they would be highly likely or likely to allow for no regular testing and 98% (136/139) were highly likely or likely to grant increased testing time. However, only 58% (74/128) would approve no standardized testing. 74% (100/135) stated that removal of academic accommodations should be determined by a physician. **Conclusions:** These data are encouraging: signaling a willingness of principals to provide academic accommodations for concussed students. However, the data suggests a knowledge gap about the prevalence of concussion and supports a need for further education of school principals on the symptoms and sequelae of concussions. When conducting further research, student population and school resource data could help determine the impact of these variables on training, perceptions, and attitudes on concussion and return to learning.

The Effects of Concussion on Energy Expenditure in Adolescents

Bernitt CJ, Hoffmann K, Goetschius J, Walton SR, Hart JM, Malin S, Saliba SA, Resch JE: University of Virginia, Charlottesville, VA

Context: Moderate to severe traumatic brain injury has been shown to result in a global hypermetabolism post-injury. Currently, a dearth of research exists examining the effects of concussion on global resting energy expenditure (REE) and total energy expenditure (TEE) in concussed patients. **Objective:** To examine the effects of concussion on REE, TEE and caloric intake (CI) in adolescent athletes. **Design:** Case-control. **Setting:** Laboratory. **Patients or Other Participants:** Participants were concussed high school students (n = 6, 16.2 ± 1.47 years, 64.9 ± 10.37 kg, 171.24 ± 7.20 cm) and healthy matched-controls (n = 9, 16.9 + 1.45 years, 65.8 ± 7.18 kg, 173.3 ± 7.13 cm). Control participants were matched (within 10%) to concussed participants based on height, weight, age, sex, sport and position. **Interventions:** REE and TEE were assessed via indirect calorimetry using the Vmax® metabolic cart. Participants reported to the lab in a fasted state, and REE measurements were collected for 30 minutes. TEE was calculated by multiplying REE by an activity factor associated with active student (1.45 for females, 1.5 for males). CI was calculated via three-day dietary recall following the initial assessment, at 7 days, and upon reporting symptom free following a diagnosed concussion. Dietary recall data were entered into SuperTracker Software to determine daily caloric consumption. A small pilot study was conducted to assess the stability of REE, TEE, and CI across time in healthy participants. Based on the stability of these data, matched-control participants were assessed at one time-point and these values were compared to those of the concussed group at each time point **Main Outcome Measures:** Independent t-tests were used to assess for group differences in demographic variables, REE, TEE, and CI at each time point. Paired t-tests were used to assess for differences across time for REE, TEE and CI in concussed subjects. Analyses were performed with $\alpha = 0.05$. **Results:** No significant differences were observed for REE, TEE, or CI at any time point between the concussed and control participants ($p > .05$). Additionally, no significant differences were observed for REE, TEE, or CI across time points for concussed participants ($p > .05$). Despite the lack of statistically significant differences, concussed participants consumed fewer calories at each time point (633, 560, and 541, respectively) compared to healthy control participants. **Conclusions:** Our preliminary findings suggest that adolescent athletes do not experience a systemic rise in REE or TEE following a diagnosed concussion. Despite the lack of statistical significance, concussed individuals were observed to consume a fewer calories compared to healthy participants, and maintain a negative caloric balance throughout recovery. Hypocaloric diets following injury may hinder the recovery process. Therefore, clinicians must be aware of the potential for caloric imbalance following a concussion.

Free Communications, Rapid Fire Oral Presentations: Prevention and Management of Emergent Conditions

Wednesday, June 28, 2017, 5:00PM-6:15PM, Room 371; Moderator: David Berry, PhD, ATC

Effectiveness of Different Airway Management Devices at Providing Quality Ventilations in Different Helmet Conditions

Boergers RJ, Bowman TG, Lininger MR, Kearn RC, Stoltz KE: Seton Hall University, South Orange, NJ; Lynchburg College, Lynchburg, VA; Northern Arizona University, Flagstaff, AZ

Context: Airway management is a critical step in the management of catastrophic injuries. Patient ventilation has been found to be compromised due to the inability to make a seal of a pocket mask over the chinstrap of football helmets. The impact of supraglottic airways such as the King airway and the impact of lacrosse helmets have not been studied. **Objective:** To assess the impact of different airway management devices and helmet conditions at providing quality ventilations while performing CPR on high fidelity manikins. **Design:** Crossover study. **Setting:** Simulation laboratory. **Patients or Other Participants:** Thirty-six (12 Males: 33.3±9.7 years old; 24 females: 33.4±9.8 years old) athletic trainers with current professional rescuer level CPR (26 American Heart Association; 10 American Red Cross) participated. **Interventions:** Participant pairs performed 2 minutes of 2 rescuer CPR in 12 trial conditions on Resusci Anne Q-CPR manikin (Laerdal Medical Corporation, Wappingers Falls, NY). The two independent variables were: airway management device (PM = pocket mask, OPA = oralpharyngeal airway, KA = King airway) and helmet condition (NH = no helmet, CH = Cascade helmet, WH = Warrior helmet, SH = Schutt helmet). All helmets were placed on the manikin with the facemask removed and chinstrap fastened. All data collection sessions were counterbalanced. **Main Outcome Measures:** The dependent variables were ventilation volume (mL) and ventilation rate (ventilations/minute). A MANOVA was used to evaluate the interactive effects of airway management device and helmet condition on ventilation volume and rate. **Results:** There was a significant interaction between helmet condition and airway management device on ventilation volume and rate ($F_{12,408} = 2.902$, $P < .0001$). There was a significant interaction between helmet condition and the airway management device for ventilation rate ($F_{6,204} = 3.468$, $P = .003$). For the NH condition, there were no differences between pairwise comparisons of airway management devices. For the CH and WH conditions, the ventilation rate for both the PM (CH: 3.0 ± 2.2 and WH: 2.8 ± 2.8) and OPA (CH: 2.8 ± 2.6 and WH: 2.5 ± 2.5) were significantly lower than the KA (CH: 5.3 ± 0.9 and WH: 5.9 ± 0.7). There was also a significant interaction between helmet condition and airway management device for mean ventilation volume ($F_{6, 204} = 3.735$, $P = .002$). There were no differences during the NH condition. For all helmet conditions, there were significant differences between the PM (CH: 277.6 ± 149.3, WH: 249.3 ± 269.3, and SH: 354.6 ± 75.3) and KA (CH: 254.5 ± 211.6, WH: 267.2 ± 215.3, and SH: 404.7 ± 197.5) airway management devices as well as between the OPA (CH: 597.1 ± 217.1, WH: 605.7 ± 248.8, and SH: 788.0 ± 294.0) and KA. **Conclusions:** The helmet chinstrap inhibits quality ventilation (rate and volume) in airway procedures which require the seal of a mask with the face. However, the KA, a supraglottic airway, will allow quality ventilation of patients with a helmet on and chinstrap fastened. If a KA is not available, the helmet may need to be removed to provide quality ventilations to the patient.

Epidemiology of Injuries Requiring Emergency Transport Among College and High School Student-Athletes

Hirschhorn RM, Dompier TP, Wasserman EB, Kay MC, Clifton DR, Kerr ZY, Yeargin S: University of South Carolina, Columbia, SC; Datalys Center for Sports Injury Research and Prevention, Inc, Indianapolis, IN; The University of North Carolina, Chapel Hill, NC; The Ohio State University, Columbus, OH

Context: There is a lack of research regarding the epidemiology of emergency transport incidents (ETI) of sports-related injuries in high school and collegiate settings. **Objective:** To determine frequency and type of ETI as a result of athletic participation. **Design:** Descriptive epidemiological study. **Setting:** National Athletic Treatment, Injury and Outcomes Network (2011/12-2013/14) and National Collegiate Athletic Association Injury Surveillance Program (2009/10-2014/15) in 25 male and female sports. **Patients or Other Participants:** High school and collegiate student-athletes. **Interventions:** ETI data were collected by athletic trainers (AT) who attended each practice and game. ATs also collected data on athlete-exposures (AEs) as defined by one athlete participating in one practice or game. **Main Outcome Measures:** Injury frequencies, injury proportion ratios (IPR), and injury rates per 10,000 AEs with 95% confidence intervals (CIs) were reported. For each ETI, the body part, final diagnosis and injury mechanism were reported by the documenting AT. **Results:** A total of 339 ETIs were reported over 2,105 college team-seasons and 146 over 1,845 high school team-seasons. ETIs represented 1.02% and 0.31% of all injuries, respectively. Women's ice hockey had the highest ETI rate at 1.30/10,000 AE (95% CI: 0.72-1.89) of all collegiate sports; however, football had the highest number of ETI (n = 121). In high school, football

had the highest rate at 0.80/10,000 AE (95% CI: 0.64-0.97) and the highest number (n = 89). Head/face injuries were the most frequently transported injuries in college (n = 71, 20.9%) and high school (n = 33, 22.6%) across all sports. This differs from collegiate football which most frequently transported neck injuries (n = 26, 21.5%). The proportion of trunk injuries requiring emergency transportation was higher in college than high school (IPR = 9.56; 95% CI: 1.27-71.76). Heat-related events accounted for 5.6% (n = 19) and 4.1% (n = 6) of ETIs in college and high school, respectively. Strain was the leading diagnosis in college (n = 23, 14.7%). Fractures were the leading diagnosis in high school, accounting for 24% (n = 35) of emergency transports. Player contact was the leading mechanism of injury in all collegiate (41.6%) and high school (54.8%) sports. **Conclusions:** Women's ice hockey had the highest rate, whereas football had the highest number of ETI in college. Football had the highest rate and number of ETI in high school. ATs should maintain a high level of emergency preparedness when working with these sports. Injuries to the head, neck and face, including concussions, are the most frequently transported across competition levels. ATs need to have the appropriate equipment and protocols in place to handle the most common injuries. Strains were the leading diagnosis in college, which are not considered an emergent condition. Future research should examine differences between field and hospital diagnosis to help improve prehospital care and decrease the likelihood of unnecessary emergency transports.

Factors That Affect Removal Time Of The Riddell Speed Flex Face Mask

Henrie TJ, Mesia L, Braun T, Moffit DM: Idaho State University, Pocatello, ID

Context: In football, cervical spine injuries may result in respiratory compromise. Quick release face guard systems aid athletic trainers, allowing quick airway access. The technological advancement of quick release systems allows the injured athlete to receive oxygen more quickly than traditional helmets, and helps avoid anoxia that can occur. This study examines face mask removal time based on various demographic variables. **Objective:** To examine the relationship between multiple demographic variables and the average removal time of the Quick Release Face Guard Attachment System on a Riddell Speedflex Helmet. **Design:** Cross-sectional. **Setting:** Turf football field. **Patients or Other Participants:** A convenient sample of twenty certified athletic trainers (Males, n = 7, age = 34.42 ± 9.19 years; Females n = 13, age = 29.30 ± 8.64 years) participated in the study. **Interventions:** Participants completed a demographic survey (e.g., years of certified athletic training experience, football coverage experience, sport setting, education level, and prior experience with Speedflex helmets). Following an informative session and two practice trials, each participant completed three timed trials. The average of the three trials for each participant was utilized for analyses. **Main Outcome Measures:** Independent variables included means, standard deviations, percentages, and frequencies. Pearson's product moment correlations determined relationships between the independent and dependent variables. Alpha level was set a priori $p \leq .05$. **Results:** Average face mask removal time was 12.15 ± 0.88 seconds. Weak correlations were found between independent variables and the average removal time (years of certified athletic training experience r = 0.02, football coverage experience r = 0.24, sport setting r = -0.13, education level r = 0.13, prior experience with Speedflex helmet r = 0.16). **Conclusions:** The lack of significant correlations suggests that quick release system face masks may be quickly removed by certified athletic trainers with minimal familiarization or education. This quick release system will allow responders to access the airway more quickly thereby avoiding anoxia, and allow for less complicated full helmet removal, if deemed necessary. This system will improve the face mask removal protocol process when responders take care of such injuries in football. Future research should compare the removal times by athletic trainers, coaches, parents, EMS, and emergency room physicians. Research should also compare the Speedflex helmet system to other new helmet quick release systems.

Bilateral Shoulder Dislocations Following a Motocross Accident

Schroepfer HJ, Martin BM, Millett PJ: The Steadman Clinic, Vail, CO; The Steadman Philippon Research Institute, Vail, CO

Background: A 22 year old male professional motocross racer presented six days status-post bilateral traumatic shoulder dislocations that occurred during competition. He sustained a left shoulder posterior dislocation and right shoulder anterior dislocation. Both shoulders were reduced on the scene. The patient denied prior injury to either shoulder. **Differential Diagnosis:** Left shoulder: labral tear, rotator cuff tear, humeral head fracture, acromioclavicular joint sprain. Right shoulder: humeral head fracture, acromioclavicular joint sprain, clavicle fracture, biceps tendonitis. **Treatment:** Physical examination of the left shoulder revealed swelling and ecchymosis over the posterior lateral border of the scapula and the proximal biceps, and point tenderness over the posterior joint line and anteriorly over the lesser tuberosity. ROM was limited in external rotation(ER) to 5°, and abduction to 70° due to pain. Subscapularis manual muscle testing was 2/5 and infraspinatus and supraspinatus were 3/5. Sulcus sign was negative, but there was increased translation posteriorly with load and shift. Radiographs showed that both glenohumeral joints were reduced with no fractures. MRI revealed complete tear of the subscapularis, partial tear of supraspinatus and infraspinatus, medial dislocation of the long head of the biceps tendon and avulsion of the anterior glenohumeral ligaments. Physical exam of the right shoulder revealed mild tenderness over the coracoid and grade 2 glenohumeral anterior translation. ROM was limited in ER to 20°, abduction to 100°, and forward elevation to 130°. Radiographs revealed a bony-Bankart lesion of the anterior inferior glenoid and a small Hill Sachs lesion. MRI showed a Hill-Sachs lesion and bony-Bankart lesion with disruption of the inferior glenohumeral ligaments. The patient underwent left shoulder open repair of massive rotator cuff tear that involved the subscapularis and supraspinatus, biceps tenodesis, and extensive debridement. Left shoulder rehabilitation included passive ROM(PROM) of 120° forward flexion, 30° ER, IR to the body and 90 °ABD for the first 4 weeks post-operatively. Full active ROM(AROM) started at 4-6 weeks. A sling was worn for 4-6 weeks post-operatively. Approximately 2½ weeks after initial surgery, right shoulder surgery was performed including extensive debridement, removal of loose body, microfracture of humeral head defect, and Bankart repair. The shoulder was immobilized for 2 weeks, and then Pendulums and PROM began. He was limited to 30° of ER from weeks 2-6. Active and active-assisted ROM began at week 5. The patient returned to full competition 6 months after the initial surgery and was doing great with no complications at 1 year follow-up. He is currently ranked number 2 in the world. **Uniqueness:** Anterior and posterior shoulder dislocations happening simultaneously are very uncommon. Anterior dislocations occur in about 95% of cases, and posterior dislocations occur in 2-10% of cases1,3. Massive rotator cuff tears are not normally seen in the younger population except in massive trauma accidents, but they are common in older patients with shoulder dislocations. In patients less than 40 years old who sustain major trauma, the diagnosis of RC tear should be considered2. **Conclusions:** A professional motocross racer experienced a high speed traumatic accident which resulted in bilateral shoulder dislocations with a rare associated complete anterosuperior RC tear due to a posterior dislocation. Although index of suspicion of RC tear may be low in most athletes with shoulder dislocations, athletic trainers should evaluate for RC tears with shoulder dislocations that occur with high energy. RC tears in the young active populations need to be treated surgically when they occur. Additionally, surgical stabilization of shoulder instability is preferred in young active patients to allow them to return to sports and decrease the risk of recurrent instability. The patient was back racing competitively 6 months status-post bilateral shoulder dislocations.

Usability and Tolerability of Novel Brain Injury Prevention Device Used in High School Football

Barber Foss KD, Roth SD, Cohen G, Thomas S, Smith DW, Myer GD: Cincinnati Children's Hospital, Cincinnati, OH

Context: According to the Center for Disease Control (CDC), an estimated 1.6 to 3.8 million mild traumatic brain injuries occur each year in the United States. Given the magnitude and potential long term consequences of this injury, the focus on prevention of sports related traumatic brain injury (sTBI) is paramount. Despite intense societal effort, little change in the rate or severity of TBI has been accomplished. An innovative device designed to enhance brain dynamics via jugular compression and resultant engorgement of the cerebrovascular tree was recently tested on high school football players. **Objective:** The purpose of the present study was to acquire participant feedback regarding their experience using the jugular compression collar across a high school football season. **Design:** Prospective cohort. **Setting:** One season of High School football. **Patients or Other Participants:** A total of 31 adolescent male athletes participated in this study. **Interventions:** The questions of this study's survey fit into 3 primary categories: "collar's use and experience", "effect on performance", and lastly, "care and storage", and all were scored using an eleven-point Likert Scale (-5 to -2 – negative response/no/infrequent, -1 to +1 – neutral response, +2 to +5 – positive response/yes/frequent). **Main Outcome Measures:** A survey was created and distributed among the study participants. Results were received from all 31 of the participating high school football players to investigate their collective experiences when using the Q-Collar during the football season. The average length of time in which the collar was worn (pre-season orientation date until post testing) was 129.7 +/- 14.9 days (range 95-154 days), which also included post-season tournament play. The survey was completed as

part of the athlete's post-season testing in conjunction with a larger study. The study participants demonstrated an overall 88.7% total compliance (days of wear during impact practice or competition/ days possible) of collar usage as prescribed by the study protocol. **Results:** All players reported 1) an overall positive experience using the collar, 2) feeling an increased sense of protection when wearing the device (0% negative responses), 3) a perceived improved performance and heightened maximum effort on the field (0% negative responses), 4) 94% of the athletes reported that they would continue to wear the device if made available in the future, 5) players also reported little to no discomfort while wearing the device. **Conclusions:** The results of this high school football study indicate that a jugular compression collar device designed to enhance intracranial resistance to external head impacts via mild jugular compression was well received, utilized, and tolerated by high school football players.

The Association Between Chest Compression Fraction to Survival at Discharge Following Out-of-Hospital Sudden Cardiac Arrest Events: A Systematic Review

Bell R, Nicolai M, Anderson C, Berry DC, Kabay M: Saginaw Valley State University, University Center, MI

Context: Chest compression fraction (CCF) is a measure of the proportion of time chest compressions are performed during sudden cardiac arrest (SCA) events. Increased CCF is achieved by minimizing pauses in chest compressions; however, CCF's association with survival-to-discharge is unclear. **Objective:** Systematically review, evaluate, and summarize literature to determine impact of CCF on survival-to-discharge after experiencing an out-of-hospital SCA event. **Data Sources:** Relevant electronic databases were searched: Pubmed, Medline, and CINHAL between January 2009-November 2016 using: (1) "chest compression" OR "chest compression fraction" AND adults AND survival AND "out-of-hospital", resulting in 161 articles. **Study Selection:** After title and abstract screening, 26 articles were read for possible inclusion. Seven articles were included based on the inclusion criteria: (1) peer-reviewed full-reports or abstracts, (2) prospective cohort studies, (3) English language, (4) available abstract, (5) patients received out-of-hospital CPR by an emergency medical service (EMS) provider, (6) performance of manual, not mechanical CPR and (7) included key outcome measuring survival-to-discharge from out-of-hospital SCA events. **Data Extraction:** Three reviewers independently assessed the level of evidence (LOE) using the Oxford (Center for Evidence Based Medicine) and Strengthening the Reporting of Observation Studies in Epidemiology (STROBE) scales. Data of interest included: subjects, CCF, time-to-first shock, and key outcome data (ie., descriptive and inferential statistics, odds ratio and confidence interval). **Data Synthesis:** Seven studies (LOE 2b = 7) met inclusion criteria, all full-reports. STROBE scores ranged from 17-21 (maximum calculated score = 22), mean = 18.8 ± 1.12. The pooled sample size, 4,589; mean calculated age, 65.3 ± 2.54 (n = 6) with all subjects experiencing an out-of-hospital SCA event. In all studies, CCF was measured using a portable defibrillator monitor and no electrical shocks were administered prior to CPR. Five studies calculated odds ratio measuring the association between CCF and survival-to-discharge, and two studies calculated mean CCF and survival rate to measure the same association. The mean odds ratio of 0.85 ± 0.11 (range = 0.30-1.11; CI = 0.69 ± 0.35, 0.99 ± 0.20) from five studies suggests that CCF (mean = 65% ± 10%, range = 50%-74%) was not associated with higher odds of survival-to-discharge from an SCA event. Two studies found CCF was associated with higher percentage of survival-to-discharge with an average CCF of 72% ± 8.0%, resulting in a mean survival rate of 17.4% ± 13.4% (range 7.8%-27%). **Conclusions:** Evidence involving the consequences of chest compression interruptions was derived from observational out-of-hospital SCA, providing heterogeneous results. The studies do not demonstrate a higher odd of survival-to-hospital discharge following a SCA event with minimized interruptions in chest compression (higher CCF value) during the perishock period. Athletic trainers should account for other possible variables influencing survival from a SCA event since a single variable does not have a strong impact, rather, emphasis of training should be on delivery high-quality CPR until the optimal goal for CCF has been defined for improved odds of survival. Conclusions: Evidence involving the consequences of chest compression interruptions was derived from observational out-of-hospital SCA, providing heterogeneous results. The studies do not demonstrate a higher odd of survival-to-hospital discharge following a SCA event with minimized interruptions in chest compression (higher CCF value) during the perishock period. Athletic trainers should account for other possible variables influencing survival from a SCA event since a single variable does not have a strong impact, rather, emphasis of training should be on delivery high-quality CPR until the optimal goal for CCF has been defined for improved odds of survival.

Opinions of Medical Professionals on the Effectiveness of Three Spine Immobilization Techniques in a Gymnastics Pit

Bonacci J, Morgan M, Phillips A, Reese T, Sexton S, Hardeman A, Fredrick M, McDermott B: University of Arkansas, Fayetteville, AR

Context: Current immobilization and extraction techniques of spine injured athlete in a gymnastics pit recommend rescuers lie in the prone position on gymnastics mats of different densities (unstable) bridged to the patient. The method of rescuing without the use of mats (stable – entering the pit), with thin mats, and with thick mats has not been compared. Objective: Assess opinions of ATs and Emergency Medical Technicians (EMTs) of the stable and two unstable rescue techniques after reading written instructions and after performing the three methods of rescue. **Design:** Pretest-Posttest Nonequivalent Groups Quasi-Experiment. **Setting:** Gymanstic pit facility Content validity of our 12-item pre-survey and 14-item post-survey was verified by an 11 member panel with a minimum of ten years of professional experience (5 ATs, 5EMTs, and 1 EMT-educator). The experts provided feedback on the appropriateness of the survey questions as they pertained to the outcome goals. **Patients or Other Participants:** A convenience sample of 17 ATs and 22 EMTs (N = 39; 30 males and 9 females) with mean age of 29 ± 6.85 years and 0 to 20 years of experience voluntarily participated. **Interventions:** Participants signed an informed consent form and were given written instructions, supplemented with photographs of the rescue technique. Each participant completed a survey prior to and after completing the three rescue techniques in a random order in the gymnastics pit and provided his or her professional opinion of the effectiveness of each rescue technique (stable, unstable thin, unstable thick). Each trial was performed with the same rescue subject for the entirety of the study **Main Outcome Measures:** Participants performed all three rescue techniques with the victim supine in the gymnastics pit. Pre- and post-survey results were compared using chi-square goodness of fit. **Results:** Post application participants favored the stable rescue method ($X^2 = 25.32$, $p < 0.001$) combined with ease in applying the C-collar ($X^2 = 11.89$, $p < 0.003$) and least amount of movement of the victim when log-rolling onto the spine board ($X^2 = 6.93$, $p < 0.03$). **Conclusions:** Based on our data, the professional opinion of ATs and EMTs was that the stable method of rescue provided the greatest amount of stability to the rescuer. After patient extraction practice, medical professionals preferred the stable method for effective application for stability of the rescuer and application of the cervical collar and spine board when an injured patient is in a gymnastics pit.

Free Communications, Rapid Fire Oral Presentations: Injury Surveillance and Epidemiology

Thursday, June 29, 2017, 7:00AM-7:45AM, Room 371; Moderator: Zachary Kerr, PhD, MPH, MA

The Epidemiology of Musculoskeletal Coxofemoral Injuries in the National Athletic Treatment Injury and Outcomes Network, 2011/12 to 2013/14 Academic Years

Dalton SL, Wasserman EB, Dompier TP: Datalys Center for Sports Injury Research and Prevention, Inc, Indianapolis, IN

Context: Participation in nearly all athletic activities requires force generation through the coxofemoral joint, bearing loads of up to 8 times one's body weight while jogging. At the body's center of gravity, the anatomy of this joint and the surrounding musculature is very complex. Therefore, student-athletes are susceptible to musculoskeletal injuries at this location, which poses difficulties for prevention and management of injuries. **Objective:** To describe the epidemiology of musculoskeletal coxofemoral injuries reported by athletic trainers in 27 secondary school boys' and girls' sports. **Design:** Descriptive epidemiology. **Setting:** Aggregate injury and exposure data from 27 secondary school sports. **Patients or Other Participants:** Boys and girls secondary school student-athletes from 107 institutions representing 2,337 team-seasons participating in the National Athletic Treatment Injury and Outcomes Network (NATION) during the 2011/12 to 2013/14 academic years. **Interventions:** Athletic trainers reported musculoskeletal coxofemoral injuries occurring during athletic participation and athlete-exposures (AEs). **Main Outcome Measures:** Injury rates per 10,000 AEs and rate ratios (RRs) were reported with 95% confidence intervals (CIs). **Results:** A total of 2,917 injuries were reported in 5,146,355 AEs, resulting in an overall rate of 5.67 injuries per 10,000 AEs (95% CI: 5.46, 5.87). Of these, 580 (20%) injuries occurred in competitions while 2,337 (80%) occurred in practices, resulting in rates of 5.46/10,000AEs (95% CI: 5.01, 5.90) and 5.72/10,000AEs (95% CI: 5.49, 5.95), respectively. The rates were similar between event types (RR = 1.05, 95% CI: 0.96, 1.15). In sex-comparable sports, girls had a higher rate of injury than boys, at 5.49/10,000AEs (95% CI: 5.11, 5.87) and 4.87/10,000AEs (95% CI: 4.55, 5.18), respectively (RR = 1.13; 95% CI: 1.03, 1.24). The highest rate of injury in girls' sports was in indoor track and field hockey, while the highest in boys' sports was football and soccer. Overall, the most common diagnoses were "other hip injury" (20.1%), adductor strains (18%), hip flexor strains (18%), contusions (13%), and abrasions (11%). Of all injuries, 89% resulted in participating restriction of less than 24 hours. The most common mechanism of injury was non-contact (33%), followed by player contact (28%). **Conclusions:** Overall, musculoskeletal coxofemoral injury rates were higher in girls than boys, which may be partially attributable to anatomical differences between sexes. The sports with the highest rates of injury are predominantly lower extremity sports requiring long bouts of running or agility and quick acceleration/deceleration. The most common injury mechanism of non-contact may be attributable to the complex anatomy of the coxofemoral joint, highlighting the importance of prevention programs that include strength training as well as flexibility. Future research should examine recurrent musculoskeletal coxofemoral injuries and the effect of increased rehabilitation on preventing such injuries.

Epidemiology of Low Back Injuries Sustained by Secondary School Athletes: A Report From the National Athletic Treatment, Injury, and Outcomes Network

Beermann LE, Wasserman EB, Williams RM, Simon JE, Dompier TP, Kerr ZY, Valier AR: A.T. Still University, Mesa, AZ; Datalys Center for Sports Injury Research and Prevention, Indianapolis, IN; Ohio University, Athens, OH; University of North Carolina at Chapel Hill, Chapel Hill, NC

Context: Little is known about epidemiology of low back injuries in secondary school athletes and whether these injuries result in participation time loss. Knowledge of injury patterns will help target prevention and management strategies. **Objective:** To describe the epidemiology of low back injuries sustained by boys' and girls' secondary school athletes. **Design:** Descriptive epidemiology. **Setting:** One hundred seven unique schools contributed data (27 sports; 2,337 team-seasons). **Patients or Other Participants:** Boys and girls secondary school athletes participating in school-sponsored athletics during the 2011/2012 through 2013/2014 academic years. **Interventions:** Boys' and girls' injury and exposure data from the National Athletic Treatment, Injury, and Outcomes Network (NATION) were analyzed. Athletic Trainers reported injuries and athlete-exposures (AEs). **Main Outcome Measures:** Injury counts, rates, and rate ratios (IRR), were reported with 95% confidence intervals (CI). **Results:** Across all sports and event types, NATION captured 1,212 low back injuries over 3,233,840 AEs for boys' sports and 546 low back injuries over 1,912,515 AEs for girls' sports, producing rates of 3.75/10,000AE (95% CI: 3.54, 3.96) for boys and 2.85/10,000AE (95% CI: 2.62, 3.09) for girls. The rate of low back injuries in boys was slightly higher than girls (IRR: 1.31, 95%CI:

1.19, 1.45). In sex-comparable sports, rates of low back injuries were similar (IRR: 0.99, 95% CI: 0.88, 1.15). The majority of low back injuries were non-time loss (NTL) for boys' (practice: n = 394, 95.7% NTL; competition: n = 95, 93.7% NTL) and girls' (practice: n = 302, 95.4% NTL; n = 73, 90.4 NTL) sports. The highest frequency of low back injuries sustained during practice were boys' football (n = 532, IR = 5.90/10,000AE, 95% CI: 5.40, 6.40; 89.6% NTL), boys' basketball (n = 88, IR = 3.22/10,000AE, 95% CI: 2.55, 3.89; 89.8% NTL), and boys' wrestling (n = 70, IR = 3.61/10,000AE, 95% CI: 2.77, 4.46; 90.0% NTL) and sustained during competition were boys' football (n = 105, IR = 5.10/10,000AE, 95% CI: 4.13, 6.08; 89.5% NTL), boys' basketball (n = 30, IR = 3.28/10,000AE, 95% CI: 2.11, 4.46; 86.7% NTL), and girls' basketball (n = 25, IR = 3.25/10,000AE, 95% CI: 1.97, 4.52, 88.0% NTL). The highest rates of low back injuries were in crew, but the precision of the estimates was low (boys' crew: IR = 5.59/10,000AE, 95% CI: 0,13.35; girls' crew: IR = 8.74/10,000AE, 95% CI: 0,18.62). The most frequently recorded low back injuries were paralumbar muscle tears (n = 540, 30.7%), other lumbar injuries (n = 503, 28.6%), and lumbosacral spine contusions (n = 307, 17.5%). Most injuries were due to contact with a person (n = 569, 32.4%) or non-contact (n = 433, 24.6%) as opposed to overuse (n = 177, 10.1%). **Conclusions:** Rates of low back injuries in secondary school athletes are low. Low back injuries were most frequently sustained in boys' football, basketball, and wrestling, and girls' basketball. Most low back injuries were NTL, suggesting that athletes continue participating when hurt. Additional research should explore the culture of playing through injury.

Differences in Time Loss and Non-Time Loss Injury Rates by Division across National Collegiate Athletic Association Football

Wasserman EB, Djoko A, Dompier TP: Datalys Center for Sports Injury Prevention and Research, Indianapolis, IN

Context: Players from different divisions in National Collegiate Athletic Association (NCAA) football differ in size, skill and speed, which may contribute to differences in injury risk. Additionally, the number of sports medicine staff differs by division. These differences may lead to variations in the rates of injury reported across divisions. Objective: Describe non-time loss (NTL) and time loss (TL) injury incidence in football by NCAA division. **Design:** Descriptive epidemiology study. **Setting:** NCAA Injury Surveillance Program (2009/10-2014/15). **Patients or Other Participants:** Collegiate football student-athletes from 57 football programs providing 153 team-seasons of data. **Interventions:** Athletic trainers (ATs) reported injuries and athlete-exposures (AEs). **Main Outcome Measures:** TL and NTL incidence rates per 1,000 AEs by football division (i.e., Football Bowl Subdivision [FBS], Football Championship Subdivision [FCS], Division II [DII], Division III [DIII]). Rate ratios (RR) are reported with 95% confidence intervals (CI) to compare rates between divisions. RR not including 1.00 were considered statistically significant. **Results:** Across all divisions, ATs reported 5,450 (53%) TL injuries and 4,865 (47%) NTL injuries (10,315 total; TL rate = 4.85/1,000AEs; NTL rate = 4.33/1,000AEs). Overall rates were highest in FBS (11.45/1,000AEs), followed by FCS (9.43/1,000AEs). DII (7.21/1,000AEs) and DIII (7.55/1,000AEs) were similar. When breaking down by time loss, FBS rates were highest regardless of time loss status, but the magnitude of the difference was larger for NTL than TL injury rates. For NTL injuries, the rate in FBS was 36% higher than FCS (RR = 1.36; 95% CI:1.24, 1.49), 2.6 times that of DII (RR = 2.57; 95% CI:2.31, 2.85), and 2.2 times that of DIII (RR = 2.22; 95% CI:2.05, 2.39). For TL injuries, the rate in FBS was 14% higher than FCS (RR = 1.14; 95% CI:1.04, 1.25), 21% higher than DII (RR = 1.21; 95% CI:1.11, 1.31), and 17% higher than DIII (RR = 1.17; 95% CI:1.09, 1.25). Similarly, for NTL injuries, the rate in FCS was significantly higher than in DII (RR = 1.89 [95% CI:1.66, 2.15]) and DIII (RR = 1.63 [95% CI:1.46, 1.81]. This was not the case for TL injuries (FCS vs. DII RR = 1.06 [95% CI:0.95, 1.18]; FCS vs. DIII RR = 1.02 [95% CI:0.93, 1.13]). **Conclusions:** Injury rates were higher in FBS than FCS, and FCS injury rates were higher than DII and DIII. The differences among the divisions was much larger for NTL injuries than TL injuries. This may suggest that differences in injury rates are due to medical staffing differences and/or documentation practices. Further research is needed to determine whether there are injury reporting differences based on medical staffing or if differences in injuries are due to differences in drills and intensity across divisions.

Comparison of Injury Rates by Exposure Type in Collegiate Men's Soccer, 2011/12 to 2015/16 Academic Years

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Context: The technique in which injury rates are calculated/expressed has a significant effect on their interpretation. Injuries per athlete exposure is commonly used for incidence measurement in collegiate and high school sports. In the professional sports realm, especially in soccer, it is more common to use injuries per player-hour. Few studies have compared the output of these approaches. **Objective:** Compare the difference between injury rate per athlete-exposure (AE), injury rate per player-hour (PH), and injury rate per player-90-minute-game (PG) in collegiate men's soccer. **Design:** Descriptive epidemiology. **Setting:** National Collegiate Athletic Association (NCAA) Injury Surveillance Program men's soccer. **Patients or Other Participants:** Collegiate men's soccer student-athletes from 39 programs provided 80 team-seasons of data during the 2011/12 to 2015/16 academic years. **Interventions:** Athletic Trainers (AT) recorded athlete-exposures and injuries during games. Injuries included any injury evaluated by an AT or physician that occurred during participation in NCAA competition. **Main Outcome Measures:** Game injury rates were calculated per 1000 AE, per 1000 PH and per 1000 90MG. The total number of player-hours for PH was determined by multiplying the number of players on the field (11) by the number of hours in a game (1.5), and multiplying this by the number of games in the dataset. The number of player-90-minute-games for PG was calculated by multiplying the number of players on the field (11) by the number of games in the dataset. Athlete-exposure (AE) was calculated as one student-athlete participating in one competition, regardless of the amount of time spent on the field. Thus, the number of AEs for one game could be more than 11. **Results:** A total of 593 injuries and 33974 AEs were reported in 1542 games. The injury rates were 17.45 per 1000 AE (95% CI:16.05, 18.86), 23.31 per 1000 PH (95% CI: 21.43, 25.18), and 34.96 per 1000 PG (95% CI :32.15, 37.77). The rate per PG was more than double the rate per AE although both rates account for the same amount of time **Conclusions:** Our findings suggest that injury rates vary by type of denominator applied to the equation. The injury rate per player-hour in games represents an excellent alternative to the athlete-exposure. However, the lack of hours of exposure in practices, as well as the lack of a set time frame for competitions in certain sports represents an imminent limitation for using this measure.

Descriptive Epidemiology of Injuries in US High School Girls' and NCAA Women's Basketball: 2004/05-2013/14

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Context: Participation in basketball among high school and college females has increased over the past 10 years. Establishing epidemiological trends of injuries among high school and college female basketball players may help guide injury prevention efforts. **Objective:** Describe the epidemiology of injuries among high school girls' and college women's basketball. **Design:** Descriptive epidemiology study. **Setting:** High school and collegiate basketball athletics during the 2004/05-2013/14 seasons. **Patients or Other Participants:** Female high school and college basketball players participating at 100 high schools and 84 colleges/universities. **Interventions:** Injury and athlete-exposure (AE) data were collected by certified athletic trainers from two injury surveillance programs: (1) High School Reporting Information Online (HS-RIO); and (2) National Collegiate Athletic Association (NCAA) Injury Surveillance Program (ISP). **Main Outcome Measures:** Time loss injury rates per 1,000AE were calculated. A time loss injury was defined as an injury occurring during a school-sanctioned practice or competition that required medical attention and resulted in participation restriction for at least 24 hours. Proportions of injuries by body part, specific diagnosis, and mechanism of injury were calculated for each competition level. Injury rate ratios (IRR) with 95% confidence intervals

(CI) compared injury rates by competition level, event type, and school size/division. IRR with 95%CI not including 1.00 were considered statistically significant. **Results:** A total of 2,930 and 3,887 injuries occurred in female high school and college basketball, respectively. This equated to national estimates of 775,942 high school injuries and 72,264 college injuries. Total injury rates for girls' high school and women's college basketball were 1.82/1000AE and 4.96/1000AE, respectively. The total injury rate was higher in college than high school (IRR = 2.73; 95% CI: 2.60-2.86). The competition injury rate was higher than the practice injury rate at both high school (IRR = 3.03; 95% CI: 2.82-3.26) and college levels (IRR = 1.99; 95% CI: 1.86-2.12). When examining injury rates within competition levels, rates were higher among high schools with less than 1,000 students than high schools with more than 1,000 students (IRR = 1.19; 95% CI: 1.10-1.28). Additionally, Division III college basketball had higher rates than Division I (IRR = 1.14; 95% CI: 1.07-1.22) and Division II (IRR = 1.26; 95% CI: 1.15-1.38). The most common injuries, regardless of competition level, were ligament sprains, muscle/tendon strains, and concussions; most injuries affected the ankle, knee, and head/face. These injuries were commonly caused by contact with another player or non-contact mechanisms, regardless of competition level. **Conclusions:** Injury rates are greater in college basketball than high school basketball, and are greater in competitions than practices regardless of competition level. Distributions of injuries by body part, specific diagnosis, and mechanism of injury suggest that both competition levels may benefit from similar injury prevention strategies. However, variations in injury rates by school-size/division indicate that potential benefits may depend on the setting in which they are implemented.

The Epidemiology of Baseball-Related Eye Injuries Among Youth Athletes in Japan

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Context: Baseball-related eye injuries are a leading cause of injuries among young athletes based on a national database system in Japan. However, no research has been investigated in more details of the mechanism of injuries except contacting balls on their eyes. **Objective:** To describe the epidemiology of eye injuries occurred in youth baseball in Japan. **Design:** Descriptive epidemiology study. **Setting:** Junior high and high schools in Japan. **Patients or Other Participants:** Students who injured in baseball during extracurricular activities and physical education classes and who also were provided disability compensation during 2005/06 to 2014/15 academic years. **Interventions:** Injury reports utilizing the injury and accident mutual aid benefit system of Japan Sports Council was analyzed. **Main Outcome Measures:** Frequencies of sex and school level were calculated. Text mining was implemented to identify explicit mechanisms of injuries such as causes, sessions, situations, positions, and activities in the injury reports, and also those frequencies were calculated. **Results:** There were 303 baseball-related eye injuries occurred between 2005/06 to 2014/15 academic years. Most occurred 95.0% in males (n = 288) and 61.7% in high schools (n = 90 freshman, 73 sophomore, 23 junior, and 1 senior). The mechanism of injuries was 99.0% of contacting balls (n = 300). The positions were 35.0% in batters, 12.9% in fielders, and 10.6% in pitchers (n = 106, 39, and 32 respectively). The sessions were 76.9% in practice and 18.5% in games (n = 233 and 56 respectively). The situations were 35.6% in hitting practice, 28.4% in fielding practice, and 18.2% in assisting/supporting of practice (n = 108, 86, and 55 respectively). In the 108 hitting practice, there was 81.5% of contacting own batted balls during hitting practice (n = 88). In the 86 fielding practice, there were 16.3% in striking balls directly from the other directions and 15.1% in error when catching during fielding practice (n = 14 and 13 respectively). In the 55 assisting/supporting of practice, there were 27.3% in striking balls directly through a spot of baseball practice nets and 25.5% in direct hits from a close range when athletes assisted/supported the others' practice (n = 15 and 14 respectively). **Conclusions:** National database system utilized disability compensated benefit indications that baseball-related eye injuries are the highest common injuries among youth athletes in Japan. Based on this research, the contacting own batted balls during hitting practice is the specific mechanism of injury. According to the database, young athletes suffer from such injuries every year, therefore, preventive approaches need to be developed immediately. We propose some possible preventions: first, wearing a helmet attached a full face/eye guard; secondly, managing their practice fields that usually multi-groups practice at the same schedule; and thirdly, educating coaches, athletes, and their parents with potential risks of vision-threatening trauma in baseball.

Free Communications, Rapid Fire Oral Presentations: Shoulder Pain: Clinical Presentation and Management

Thursday, June 29, 2017, 8:00AM-9:00AM, Room 371; Moderator: Jason Scibek, PhD, LAT, ATC

Tennis Serve Volume and its Relationship to Injury in Professional Women's Tennis Players

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Context: Serve volume may be associated with tennis injury the same way pitch volume is related to upper limb pain in youth baseball players. However, the relationship between musculoskeletal injuries and serve volume has yet to be investigated in tennis players. **Objective:** To investigate if serves over a season and other match parameters are associated with an increased risk of upper limb or trunk injury in professional women's tennis players across a playing season. **Design:** Retrospective review. **Setting:** N/A. **Patients or Other Participants:** 277 ranked women's tennis players from the 2012, 2013, and 2014 competitive seasons. All players were ranked within the top 200 for all three seasons, 600 potential observations. **Interventions:** Two databases were queried to extract match parameters and injury records. Match parameters were obtained from the Systems Applications and Products (SAP) database while upper limb and trunk injury records were obtained from Automated Record Management System (ARMS) database. Match parameters included match serves over a season, sets played, service games played, and match minutes. To determine which match parameters were predictive of an occurrence of an upper limb or trunk injury a multiple logistic regression was utilized. **Main Outcome Measures:** The primary outcome of interest was the occurrence of upper limb or trunk injury. **Results:** Out of the potential 600 cases there were 590 cases available for analysis. 233 (39%) of those cases represented an upper limb or trunk injury while 357 (61%) of those cases represented no injuries. The average serve volume per season was 2,278 ± 1,232. Serve volume over a season was a predictor of upper limb or trunk injury ($p < 0.001$). The estimated odds ratio was 1.04 (CI 95 1.03, 1.06). None of the other match parameters were predictors of upper limb or trunk injury ($p > 0.05$). **Conclusions:** For each 100 serve increase the estimated odds of injury increase by 4%. This data is the first to investigate the relationship between match parameters and injury. Professional women's tennis players perform a large amount of overhead serves throughout a competitive season that potential places them at risk for injury. While the number of serves during a match cannot be manipulated, players can train or monitor their volume to help the body sustain the increased demands of the overhead motion.

Clinical Evaluation Findings in Patients Diagnosed With Impingement or Shoulder Pain: A Report From the Athletic Training Practice-Based Research Network

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Context: Chronic, overuse shoulder injury diagnoses present evaluation challenges. Clinical practice patterns of evaluation findings provide insight into patient case presentations and deficits following injury. **Objective:** Describe clinical presentation of patients diagnosed with shoulder impingement (IMP) or shoulder pain (SP) by athletic trainers (ATs). **Design:** Retrospective analysis of electronic medical records (EMR). **Setting:** Fifty-nine athletic training facilities in secondary school (SS, 84.7%, n = 50), and collegiate (15.3%, n = 9) settings across 13 states within the Athletic Training Practice-Based Research Network. **Patients or Other Participants:** 138 ATs (age: 29.3 ± 8.3 years; female: 65.9%, n = 91; years certified: 4.5 ± 5.8; current site employment: 1.9 ± 4.0 years) practiced at clinic settings during the study period. **Interventions:** Patient evaluation forms with IMP or SP diagnoses between October 2009-October 2016 were analyzed. Patient records were created by ATs utilizing a web-based EMR with ICD-9 diagnostic codes (IMP: 726.2, SP: 719.41). **Main Outcome Measures:** Summary statistics (percentages and frequencies) were calculated to describe evaluation findings, including sex, sport, mechanism of injury (MOI), AROM, manual muscle test (MMT), neurological and special tests. **Results:** ATs diagnosed 77 IMP (SS: 61%, n = 47/77; college: 39%, n = 30/77; age: 17.2 ± 2.5 years) and 94 SP (SS: 71.3%, n = 67/94; college: 27.7%, n = 26/94; age: 16.4 ± 2.2 years) injuries. At evaluation, shorter symptom duration was reported for IMP than SP (IMP: 15.8 ± 35.4 days; SP:

42.9 ± 146.8 days). Females comprised most of the IMP patients (58.4%, n = 45) whereas more males comprised SP patients (60.6%, n = 57/94). Common sports played by patients diagnosed with IMP were volleyball (22.1%, n = 17/77), softball (15.6%, n = 12/77) and football (14.3%, n = 11/77) and SP were football (23.4%, n = 22/94), swimming (14.9%, n = 14/94) and baseball (10.6%, n = 10/94). The most common MOIs of non-contact (IMP: 55.8%, n = 43/77; SP: 52.1%, n = 49/94), insidious onset (IMP: 24.7%, n = 19/77; SP: 20.2%, n = 19/94) and contact (IMP: 13.0%, n = 10/77; SP: 21.3%, n = 20/94) were similar between diagnoses as was reported pain at evaluation (IMP: 5.1 ± 2.0; SP: 4.5 ± 2.2 points out of 10). Most patients were playing without restriction (IMP: 98.7%, n = 76/77; SP: 98.8%, n = 91/94). Fewer AROM limitations were displayed in IMP than SP (moderate-to-severe:14.3%, n = 11/77 v. 18.1%, n = 1794; mild: 22.1%, n = 17/77 v. 28.7%, n = 27/94; within normal limits: 63.6%, n = 49/77 v. 50%, n = 47/94), respectively. MTT strength deficits (≤4/5) for IMP were empty can (74%, n = 29/39) and abduction (52%, n = 31/60) whereas SP displayed greatest deficits with abduction (52%, n = 32/62), external rotation (50%, n = 25/50) and flexion (48%, n = 32/62). IMP and SP patients displayed normal neurological status, except for diminished light touch sensation in SP (13.3%, n = 2/15). Approximately four special tests were performed per patient. Both groups frequently displayed positive Hawkins-Kennedy tests (IMP: 85%, n = 47/55; SP: 50%, n = 21/42). Neer's impingement was also frequently positive for IMP (75.5%, n = 34/45) whereas apprehension was frequently positive for SP (26.5%, n = 13/49). **Conclusions:** While many similarities in clinical presentation exist between IMP and SP, differences in symptom duration, prevalence between sexes, AROM limitations, and strength deficits exist, which may help educate ATs on recognizing key clinical findings to aid in diagnosis.

Observational Scapular Dyskinesis: Prevalence in Individuals With and Without Shoulder Pain

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Context: Altered position and movement of the scapula, defined as scapular dyskinesis, has been implicated as a cause of shoulder pain. However, current evidence has failed to provide clear support for this relationship. **Objective:** Characterize the prevalence of scapular dyskinesis in participants with shoulder pain and healthy controls, and to determine the influence of arm dominance on prevalence of dyskinesis. It was hypothesized (1) participants with shoulder pain would have a similar prevalence of scapular dyskinesis compared to healthy controls, and (2) prevalence of dyskinesis would be similar between the dominant and non-dominant arms in healthy participants. **Design:** Prospective cohort. **Setting:** Outpatient clinics. **Patients or Other Participants:** Potential participants were screened during the treating clinician's initial evaluation. Participants in the shoulder pain group were required to have pain ≥2/10 on the numeric pain rating scale. Participants in the control group did not have a history of shoulder pain within the past year. A power analysis indicated 108 participants for 80% power, alpha of 0.05. Participants (n = 135); n = 67 shoulder pain group (32.5 ± 12.4 years, 33 females); n = 68 healthy controls (27.8 ± 8.7 years, 41 females). **Interventions:** The scapular dyskinesis test (SDT) was performed as described by McClure et al. (2009) by an examiner who was blinded to participant group (shoulder pain, healthy control). The SDT was performed during weighted active flexion and abduction. Dyskinesis was rated as normal, subtle, or obvious for winging or dysrhythmia. For data analysis, normal was classified (-) dyskinesis, while subtle and obvious defined (+) dyskinesis. Arm dominance was matched for comparisons between the shoulder pain and healthy control groups. Chi-square tests were performed with significance set at $p \leq 0.05$. **Main Outcome Measures:** Dependent variables were prevalence of dyskinesis by group, and by arm dominance. **Results:** There were no significant differences between the shoulder pain and control groups for the prevalence of dyskinesis in flexion ($p = 0.512$) or abduction ($p = 0.092$). The shoulder pain and healthy control group respectively, had dyskinesis of 45/67 (67.2%; 95% CI 0.55,0.77) and 42/68 (61.8%; 95% CI 0.50,0.72) during flexion, and 45/67 (67.2%; 95% CI 0.55,0.77) and 36/68 (52.9%; 95% CI 0.41,0.64) during abduction. Scapular dyskinesis prevalence was not significantly different for arm dominance in flexion ($p = 0.529$) or abduction ($p = 0.649$). When the SDT was performed in flexion and abduction respectively, there was 20/34 (58.8%; 95% CI 0.42,0.74) and 17/34 (50%; 95% CI 0.34,0.66) prevalence of dyskinesis in the dominant arm, and 21/34 (61.8%; 95% CI 0.45,0.76) and 19/34 (55.9%; 95% CI 0.34,0.66) prevalence in the non-dominant arm. **Conclusions:** Prevalence of scapular dyskinesis does not appear to be influenced by shoulder pain, or by arm dominance. Scapular dyskinesis may represent normal movement variability. Therefore, addressing scapular dyskinesis during treatment may not be warranted, unless scapular symptom alteration tests decrease symptoms.

Significantly Increased Odds of Reporting Previous Shoulder Injury in Females Based on Larger Magnitude Shoulder Rotator Side-to-Side Strength Differences

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Context: Musculoskeletal injuries are a primary concern for the United States military. One possible risk factor for injury in this population is side-to-side strength imbalance. Increased odds (1.8-3.3) of reporting lower extremity and/or knee injuries in military Special Forces Operators with greater magnitude side-to-side knee strength differences have previously been demonstrated, but no study to date has investigated this relationship in the upper extremity and female military personnel. **Objective:** To examine the odds of reporting a previous shoulder injury (SI) in US Marines Ground Combat Element Integrated Task Force volunteers based on the magnitude of side-to-side strength differences (StoSD) in isokinetic shoulder strength. **Design:** Retrospective cohort study **Setting:** Research laboratory **Patients or Other Participants:** 207 Marines volunteered to participate at Camp LeJeune, North Carolina in 2014. Male (n = 154, age: 22.6 ± 2.6 years, height: 69.8 ± 2.6 inches, weight: 178.9 ± 22.2 pounds) and female (n = 53, age: 22.6 ± 2.9 years, height: 65.0 ± 2.3 inches, weight: 144.3 ± 15.3 pounds) Marines were tested. **Interventions:** Self-reported injury history and isokinetic strength testing on shoulder musculature was acquired. Injury history was obtained by a clinician. Peak torque from 5 shoulder internal/external rotation repetitions were averaged and normalized to body weight. StoSD were calculated as the absolute value of the difference between limbs and dividing it by average peak torque of the dominant limb. **Main Outcome Measures:** Subjects were placed into cohorts based on the magnitude of their shoulder rotator StoSD: <10%, 10-20%, and >20%. Odds ratios and 95% confidence intervals were calculated, and significance was assessed using a chi-square test with alpha set at <0.05 a priori. These methods were repeated when separating subjects into gender cohorts. **Results:** As a combined cohort, Marines with >20% difference in side-to-side internal rotation strength demonstrated increased odds or reporting a previous SI compared to those with <10% differences (OR = 2.5, 95% CI: (1.0-5.9); p = 0.036). When separating Marines by sex, females with >20% internal rotation StoSD demonstrated increased odds of reporting a previous SI compared to female Marines with <10% StoSD (OR = 15.4, 95% CI: (1.4-167.2); p = 0.025) and female Marines with 10-20% StoSD (OR = 13.9, 95% CI: (1.3-151.2); p = 0.036). No odds ratios for the male Marine cohort were statistically significant. **Conclusions:** Marines with larger magnitude internal rotation strength StoSD demonstrated increased odds of reporting a previous SI compared to those with lesser magnitude differences. Additionally, female sex appears to drastically affect the increased odds of reporting SI (13.9-15.4) with larger magnitude differences (i.e., >20%) compared to those with lesser magnitude differences (i.e., <10% and 10-20%). Female Marines may benefit from targeted rehabilitation strategies that would improve strength balance between upper extremities after sustaining a shoulder injury. Baseline testing may be warranted in this population to identify individuals with larger magnitude StoSD and implementing a prehabilitation program to limit injury risk. This work was supported by ONR Award #N00014-14-1-0021.

Effects of Compex® as a Warm-Up for Glenohumeral Range of Motion

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Context: Warm-ups are a common practice to help prepare the body for activity. Research regarding proper upper extremity warm-up protocols remains inconclusive, especially for electrical stimulation methods like the Compex Sport Elite® unit. **Objective:** To evaluate the effectiveness of Compex Sport Elite® pre-warm up setting on improving glenohumeral range of motion (ROM) compared to a cardiorespiratory upper extremity warm-up protocol. **Design:** Crossover study. **Setting:** Laboratory. **Patients or Other Participants:** Thirty-five young adults (19 men, 16 women; age = 22 ± 2 y; height = 172.1 ± 9.4 cm; mass = 71.3 ± 16.1 kg; right-hand dominant = 28; left-hand dominant=7) with no history of upper extremity injury in the past 6 months completed the study. **Data Collection and Analysis:** Participants came to the research laboratory on two occasions, at least 48 hours apart. Participants were randomly assigned the order to complete an upper body ergometer protocol (UBE) and Compex Sport Elite®. All participants completed both intervention conditions. The UBE protocol consisted of five minutes of arm cycling at a perceived intensity of "somewhat hard" or 13 on the rating of perceived exertion scale. The Compex Sport Elite® protocol was based on manufacturer guidelines in which pads were placed near the acromioclavicular joint and inferior to the spine of the scapula on the dominant arm. Electrical stimulation was delivered for 25 minutes. Dominant arm passive glenohumeral internal rotation (IROT) and external rotation (EROT) ROM were measured before, immediately after, and 30 minutes after intervention. The average of three trials was used. The Global Rating of Change (GROC) scale was used after both

post-intervention ROM measurements. Outcome measures were recorded by a researcher blinded to the interventions. **Results:** We completed two 2 (condition) x 3 (time) repeated measures ANOVA to compare changes in IROT and EROT for UBE and Compex®. No significant interaction effect ($\lambda = 0.97$; $F_{(2,33)} = 0.54$; $p = 0.59$; ES = 0.03) or main effects were observed for IROT. For EROT, no significant interaction effect was found ($\lambda = 0.88$; $F_{(2,33)} = 2.18$; $p = 0.13$; ES = 0.12); however we found a main effect of time ($\lambda = 0.77$; $F_{(2,33)} = 5.03$; $p = 0.12$; ES = 0.234). Follow-up pairwise comparisons indicated significant increase in EROT immediately post-intervention (1.508 ± .475; $p = 0.01$) regardless of intervention. GROC values following dependent t-test resulted in no significant changes for either IROT or EROT (immediate post-intervention $t_{34} = 0.72$, $p = 0.48$; 30 minutes post-intervention $t_{34} = 0.59$, $p = 0.56$). **Conclusions:** No significant difference was found between the use of Compex® and UBE for warm-up of the glenohumeral joint. However, both interventions resulted in increased EROT immediately following application of intervention. Based on our results, either intervention is applicable for clinicians seeking short-term improvements of EROT for clinical purposes. It is recommended that clinicians select an intervention appropriate to the patient's outcome goal, which may include interventions beyond those evaluated in this study. Moreover, the ROM gains are nominal, may have no clinical relevance, and are within the margin of error for this measurement tool.

Effects of 6-Week Open Kinetic Chain and Closed Kinetic Chain Resistance Exercise Programs on Scapular Upward Rotation

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Context: Scapular muscle activation during various upper extremity open kinetic chain (OKC) and closed kinetic chain (CKC) exercises have been reported in the literature. It remains unclear if scapular kinematics are affected as a result of an OKC or CKC resistance exercise training program for the shoulder. **Objective:** To compare static scapular upward rotation position before and after 6-weeks of resistance tubing exercise in the OKC and CKC position. **Design:** Randomized controlled trial. **Setting:** Research laboratory. **Patients or Other Participants:** Thirty volunteers with no history of shoulder injury (12 males: age = 21.0 ± 1.9 years, height = 177.3 ± 4.3 cm, mass = 86.9 ± 18.6 kg; 18 females: age = 22.1 ± 2.7 years, height = 165.0 ± 4.8 cm, mass = 70.0 ± 17.1 cm). **Interventions:** Pretest scapular upward rotation on the throwing dominant arm was measured with a digital protractor at rest and at 60º, 90º and 120º of humeral elevation in the scapular plane. Three trials were performed at each position with a 30 second rest period between each trial. Order of position was randomized. The three repeated measures at each position were averaged. Participants were randomly assigned to one of three groups: OKC, CKC and control group. The OKC group performed glenohumeral internal and external rotation against resistance tubing in the standing position. The CKC group performed glenohumeral internal and external rotation against resistance tubing in a push-up position on the Standing Firm device. Exercises were performed 3 days/week for 6-weeks. Repetitions, velocity and progression of the resistance tubes were the same for both groups. Participants in the control group were not enrolled in an exercise program. All participants were instructed to refrain from upper body resistance exercises and overhead activities outside the scope of the study. Posttest upward rotation measurements were performed within 48 hours of completing the 6-week period utilizing the methods previously described. The same investigator performed the upward rotation measurements and was blinded to the group assignment. The independent variables were group (OKC, CKC and control) and time (pretest and posttest). **Main Outcome Measures**: The dependent variables were the mean upward rotation measurements at the four positions of humeral elevation (rest, 60º, 90º and 120º). For each dependent variable, a 2 x 2 factorial ANOVA was performed ($p < 0.05$). **Results:** There were main effects for time at 60º ($F1,27 = 4.523$, $p = 0.043$) and 90º ($F1,27 = 5.180$, $p = 0.031$) of humeral elevation. At 60º, the posttest (5.0 ± 4.2º) was greater than the pretest (4.5 ± 4.0º). At 90º, the posttest (18.4 ± 4.9º) was greater than the pretest (17.7 ± 4.7º). There were no other main effects or interactions. **Conclusions:** Scapular upward rotation increased at 60º and 90º of humeral elevation, however, the three groups responded similarly. Based on previously reported minimal detectable change values, these results may not be clinically significant. Future research should focus on patients with shoulder injuries and scapular dyskinesis.

Let Them Play! Conservative Management of the High School Athlete's Unstable Shoulder Results in High Return to Sport

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Context: Management following episodes of shoulder instability in young athletes is controversial with studies suggesting that conservative management increases the risk of recurrence. **Objective:** The purpose of this study was to compare the likelihood of return to same scholastic sport of injury and complete the next full season without an additional time-loss injury among athletes when considering treatment, instability type, and sport classification. **Design:** Cohort study **Setting:** High school athlete population based study. **Patients or Other Participants:** From 2011-2015 scholastic athletes at 20 high schools within one Athletic Training (AT) network that were identified by their scholastic AT as suffering a traumatic time-loss anterior shoulder instability injury (n = 129; age = 15.9 ± 1.5 years; 176.8 ± 9.5 cm; 83.5 ± 21.6 kg) related to sport participation were included in this study. These athletes tended to be male (n = 108 vs. 21) and play contact sports (n = 101 vs 28). **Interventions:** Diagnosis was documented by a Board Certified Orthopedic Surgeon and classified as a dislocation or subluxation. Conservative management included modalities, exercise program and bracing as indicated. **Main Outcome Measures:** The variable of interest was the ability of each athlete to successfully return to their index sport for the next full season. Full participation(from the first day of practice through the end of the season) in the sport of injury without subsequent time-loss was considered a successful return to sport. Chi Square and relative risk analyses were completed to compare the success of treatment type(conservative versus surgical care) and by instability type (subluxation vs dislocation). Separate logistic regressions were used to compare the impact of gender and sport classification(contact vs non contact) on the athletes' ability to return to sport within treatment types. **Results:** Ninety-seven athletes received initial conservative and 32 surgical care. Athletes treated conservatively (85%) and surgically (72%) displayed similar rates of successful returned without injury for a full season to the same sport (P = 0.11). Players sustaining a dislocation (n = 73) were less likely to successfully return compared to those sustaining a subluxation (n = 56) (74% vs. 91%; P = 0.013). Athletes sustaining anterior dislocation were at approximately 2.9 times (95% CI = 1.2-7.3) greater risk of failing to return to sport than those sustaining subluxation. Gender (P = 0.85) and sport classification (P = 0.74) did not influence the athlete's ability to return to sport regardless of treatment type. **Conclusions:** Our results show conservative care is effective for the majority of high school athletes to return to sport without a subsequent shoulder injury for the next full season. Athletes with a dislocation were almost 3x less likely to successfully return to sport compared to those sustaining a subluxation. These results suggest that the magnitude of the initial injury(dislocation or subluxation) should be strongly considered for treatment planning, prognosis of subsequent injury risk, and likelihood of return to sport. These results warrant future study.

Role of Hand Placement at Initial Contact on Peak Ground Reaction Force During a Back Handspring on Balance Beam

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Context: Back handsprings (BHS) are a common skill used in gymnastics. According to current literature, a turned-in hand position reduces peak ground reaction force at impact on floor and vault exercise, and therefore reduces risk of injury. To our knowledge no studies analyzing the role of hand placement during a BHS on balance beam exist. Understanding how hand placement during a BHS on beam changes peak ground reaction forces may help to reduce injury risk and improve coaching techniques. **Objective:** The purpose of this study was to identify the role of hand placement during BHS on balance beam in relation to peak ground reaction forces. **Design:** Cross-sectional. **Setting:** Testing was completed at two gymnastics facilities. **Patients or Other Participants:** 19 female gymnasts participated with a height (cm): 152.3 ± 8.9; mass (kg): 42.5 ± 7.9; age (years): 12.9 ± 1.9. Inclusion criteria included minimum of 4 years gymnastics experience, ability to compete a BHS on balance beam and having no practice limitations due to current injury. **Interventions:** Subjects completed 3 BHS on a balance beam. Hand placement technique, skill height (vertical), skill length (horizontal), angle of impact, and total ground reaction force at impact were analyzed. Trials were recorded with high-speed cameras (Miro3205, Phantom, Wayne, NJ). Force data was collected using portable force plates (Bertec FP4060, Bertec, Columbus, OH). Video analysis was completed using Dartfish Champions Software (Dartfish, Alpharetta, GA). **Main Outcome Measures:** Variables were compared to peak ground reaction forces. Hand placements were grouped into categories, each in relation to the parallel axis of the balance beam; neutral (both hands parallel), turned-out (one hand > 30° from parallel), turned-in (one hand < 30° from parallel), and "other". Analysis of variance and pair-wise comparisons were used to identify factors that may contribute to increased force at initial hand contact. **Results:** BHS height (m) and length (m) is presented as a ratio to standing height (m). Mean skill height: 0.61 ±0.06 and skill length: 0.58 ± 0.1. Angle of impact: 93° ± 5.8°. Peak vertical force (N) is presented as a ratio to mass (kg): 2.5 ± 0.5. Correlation coefficients found poor correlations between skill height, length, and angle of impact in relation to peak reaction force. Significance was found between hand placement and peak reaction force ($F_{(3,27)} = 15.62$; $P < .001$). "Turned-in" hand placement had significantly higher peak force compared to all other groups: Turned-In vs Neutral ($P < .05$); Turned-In vs Turned-Out ($P < .02$); Turned-In vs Other ($P < .008$). **Conclusions:** This study shows skill height, skill length, and impact angle may have little effect on peak reaction force. Hands in a "turned-in" position upon landing appear to significantly increase forces through the upper extremity, which is contrary to some of the literature.

Comparison of Traditional and Smartphone Goniometers for Elbow Motion in Female Gymnasts

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Context: Increased elbow carrying angle and range of motion (ROM) are risk factors for elbow injury. Goniometers are commonly used for measuring joint angles and ROM. Traditionally, plastic or digital goniometers are used, however, advances in technology has brought forth goniometer software applications that can be run on portal devices such as smartphones. **Objective:** The purpose of this study was to compare traditional hand-held goniometer measurements to the smartphone application Goniometer Pro (5fuf5, Bloomfield, NJ). **Design:** Cross-sectional. **Setting:** All testing was completed at two local gymnastics facilities. **Patients or Other Participants:** 38 female gymnasts. Height (cm): 150.9 ± 11.8; mass (kg): 43.7 ± 8.7; age (years): 13.2 ± 2.3. Minimum of one-year participation in gymnastics required for inclusion. **Interventions:** Elbow carrying angle, and elbow ROM were measured with a traditional hand-held goniometer and using a 7th generation iPod Touch (Apple, Cupertino, CA) with Goniometer Pro installed. All measurements were taken twice on the left and right arms. Additional measurements included height, weight, upper extremity length, and upper extremity girth. All measurements were taken by one researcher (SDR) and analyzed with standard statistical software. **Main Outcome Measures:** Traditional goniometer measurements of all 38 subjects were compared to Goniometer Pro for elbow flexion, extension, and carrying angle. Paired t-tests and Cronbach's alpha were used to determine statistical difference and test reliability. **Results:** Traditional goniometer flexion: 140° ± 4.5°, (hyper) extension: -8.1° ± 4.7°,

carrying angle: 11.8° ± 3°. Goniometer Pro flexion 159.7° ± 10.1°, (hyper)extension -7.3° ± 5.7°, carrying angle: 9.9° ± 4°. Paired student's t-tests show significant difference between traditional and application for flexion ($t = 13.2$, $P < 0.001$) and carrying angle ($t = -4.1$, $P < 0.001$). No difference was found for (hyper)extension ($t = -0.25$, $P = 0.8$). Cronbach's alpha shows good reliability for traditional goniometer and Goniometer Pro: flexion (0.95/0.90), extension (0.98/0.97), carrying angle (0.99/0.93), respectively. **Conclusions:** Goniometer Pro appears to overestimate flexion, underestimate carrying angle, and accurately measure (hyper) extension. One reason for these differences may be the axis of which these measurements are taken, and how the internal accelerometer detects changes. Additionally, Goniometer Pro may have higher accuracy with small ROM, such as (hyper)extension, compared to large ROM seen in flexion. Overall, care should be taken when using novel technology in the health care setting.

Competitive Gymnasts' Perceptions of Activity Limitations Using the Patient Specific Functional Scale Following Orthopedic Injury

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Context: Gymnastics is a high intensity sport, resulting in an increased risk of injury. Further, the culture of gymnastics warrants long training hours, enhancing the risk for over-use injuries. Gymnasts have been shown to have increased mental toughness, which further poses an injury risk. Following injury, it is important to understand and know the functional limitations gymnasts perceive in order to adequately return them back to sport participation. **Objective:** To qualitatively explore how competitive gymnasts perceive activity limitations following injury. **Design:** Cross-sectional. **Setting:** Outpatient clinic. **Patients or Other Participants:** A convenience sample of 44 patients (3 = males, 41 = females, age = 12.25 ± 3.05) participating in competitive gymnastics. **Data Collection and Analysis:** The Patient Specific Functional Scale (PSFS) was used to identify activity limitations as a result of orthopedic injury. The PSFS was administered during clinical office visits following orthopedic injury. The PSFS is a self-reported patient-rated outcome measure that asks patients to identify 3-5 activities important to the patient that are limited due to injury, and further asks patients to rate the difficulty to perform those activities on a scale of 0 (unable to perform) to 10 (no difficulty). Via consensus, a four-person research team was used to determine final themes and categories of reported activity limitations. Each researcher independently coded the data and created a preliminary codebook. Next, the research team met to discuss and finalize a consensus codebook that richly captured the activity data. To decrease researcher bias, triangulation occurred through the inclusion of multiple researchers. **Results:** Two main themes emerged following data analysis regarding gymnasts' perceptions of activity limitations following orthopedic injury. First, patients defined primary activity limitations according to basic function. This theme consisted of two categories, including (a) role-specific function (e.g., writing), and (b) general activities of daily living (e.g., sitting, standing). The second main theme was sport-related, which consisted of two categories, including (a) general exercise (e.g., running, biking), and (b) gymnastic-specific (e.g., vaulting, balance beam) **Conclusions:** Gymnasts identify the primary activity limitations following injury according to basic functions and sport-related categories. The emphasis on sports-related activities highlights and confirms the importance that being active and participating in gymnastics plays in the lives of these competitive athletes. However, it is important to note that gymnasts also identified activities of basic function as a primary activity concern as well. Attention towards basic functions and functional activities outside of sport are important to address for the overall care of competitive gymnasts. Further, emphasis on return-to-sport may take priority without knowledge of these other areas of impact. The PSFS is a helpful patient-reported measure to identify patient-specific concerns so that patient-centered care is practiced. Identifying patients' areas of concerns outside of injury limitations, enhances patient care, and improve injury outcomes.

Nested Case-Control Study of Injury Risk Factors Among Youth Volleyball Players

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Context: Injury prevention programs have demonstrated that targeted strength and stability exercises can reduce the incidence of injury. However, sport-specific skills and athlete ability vary widely between sports, age-groups and athletes. Knowing the specific risk factors for individual sports and age-groups may help create targeted injury prevention strategies and modify risk factors among children and adolescent athletes. **Objective:** To determine if individual portions of pre-season assessments may be related to injury incidence in a cohort of youth volleyball players. **Design:** Nested case-control study. **Setting:** Athletic training laboratory and field. **Patients or Other Participants:** Cohort data from volleyball players who participated in the pre-season assessment for their youth volleyball teams with parental consent was included. Fifteen athletes who sustained an injury during the club volleyball season (January to May) that was treated by the attending certified athletic trainer (AT) and fifteen controlled subjects were selected for this sub-study. Cases and controls were matched on age, height, and weight. The injured group (age: 14.63 +/- 1.50 year; height: 171.62 +/- 9.67 cm; mass: 63.08 +/- 12.08 kg) and non-injured group (age: 14.47 +/- 1.62 year; height: 173.90 +/- 9.11 cm; mass: 63.76 +/- 10.08 kg) did not differ statistically. **Interventions:** Range of motion was measured using a standard goniometer for all lower and upper extremity movement. Muscle strength was measured using a hand-held dynamometer and normalized by body weight. Dynamic postural control was measured using a modified Star Excursion Balance Test, and Overhead Squat assessment was conducted using criterion from the National Academy of Sports Medicine. All cohort subjects were monitored for injury in the 2014 Volleyball season by the AT assigned to their team. ATs completed injury evaluations consistent with their training and experience. **Main Outcome Measures:** A case injury was defined as any injury incident requiring care from team ATs, and was documented by ATs, regardless of time lost from sport. T-tests ($\alpha < 0.05$) were used to determine the differences between injured and non-injured groups. **Results:** Ankle and thigh injuries comprised the greatest proportion of cases (n = 4, 26.7% each). Strength measured by manual muscle testing was lower for injured group compared to non-injured group, however it was not statistically significant. No other variables showed a trend between the injured and non-injured group. **Conclusions:** Injured group did not differ from non-injured group for their pre-assessment measures. A small sample size, variety of injuries, and limited follow up (only 1 season) may contribute to these findings. Therefore, future studies should include a larger number of participants in order to truly investigate the risk factors of injuries among children and adolescent sport.

Pre-Season Patellar Tendon Structure and Self-Reported Function Are Not Associated in Division-I Collegiate Female Volleyball Athletes

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Context: Patellar tendinopathy is prevalent in athletes participating in jumping sports. Clinical management of tendinopathies is challenging, as relationships between tendon structure and function are not clearly defined. Ultrasound tissue characterization (UTC) quantifies tendon structural integrity, and can detect changes in tendon structure in response to loading. Understanding relationships between tendon structure and perceived function may aid in developing injury prevention interventions and load management strategies in athletes participating in high-risk sports, such as volleyball. **Objective:** To determine associations between pre-season patellar tendon (PT) structure and self-reported knee function in female collegiate volleyball athletes. **Design:** Descriptive laboratory study. **Setting:** Research laboratory. **Patients or Other Participants:** Fourteen Division-I female volleyball athletes (age 19.54 ± 1.33 yrs; height 182.44 ± 8.40 cm; mass 76.08 ± 9.09 kg) participated in this study. **Interventions:** Participants lay supine with knee bent to approximately 100°. The UTC scanner used a 10-MHz linear-array transducer (Terason2000; Teratech, USA) mounted in a tracking device with a motor-drive and built-in acoustic stand-off pad (UTC Tracker, UTC Imaging). The device moved the probe along the patellar tendon, capturing images at 0.2mm intervals (focus = 1.3cm, depth = 3 cm). A 3-dimensional data block was created; tissue characterization was quantified by UTC algorithms based on the stability of pixel brightness over every 25 contiguous transverse images into 4 echo-types (I-IV): (I) intact &

aligned tendon bundles, (II) less integer & waving tendon bundles, (III) mainly fibrillar tissue, (IV) mainly amorphous matrix with loose fibrils, cells, fluid. The right knees of participants were scanned. Tendon borders were outlined manually in the transverse view every 20 frames across the proximal 2.5 cm of the PT; contours were interpolated to generate echo-type (I-IV) percentages (%). Participants completed the Victorian Institute of Sport-Patellar Tendon (VISA-P) questionnaire (PT pain and knee function). **Main Outcome Measures:** Separate Pearson product moment correlations were performed to assess associations between UTC echo-type % (I-IV) with VISA-P scores ($\alpha = 0.05$). **Results:** There were no statistically significant associations between VISA-P (mean ± sd: 78.21 ± 16.83) scores and PT UTC echo-type % (type I: 51.31 ± 4.78%; $r = -2.90$, $p = 0.32$; type II: 44.62 ± 3.32%; $r = 0.44$, $p = 0.11$; type III 3.61 ± 2.01%; $r = -0.03$, $p = 0.92$; type IV: 0.47 ± 0.36%; $r = -0.02$, $p = 0.94$). **Conclusions:** Our results indicate that pre-season self-reported knee function and PT tendon structural integrity are not associated in female collegiate volleyball athletes. There was a trend towards increased Type II % to associate with improved VISA-P scores, but this was not a significant relationship. Overall, these findings support current knowledge indicating the relationship between tendon structure and function is complex. Future research should assess how changes in PT structure and self reported function over a competitive season are associated in high-risk jumping athletes.

Prospective Study of Golf-Related Injuries in Korean Female Professional Golfers, 2016 Season

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Context: Despite its popularity, the prospective studies on golf-related injuries among professional golfers are limited in the literature. **Objective:** To analyze the golf injury rates, injury sites, injury mechanisms between levels of play and a possible risk factors of Korean female professional golfers in 2016 season. **Design:** Prospective study. **Setting:** Korea Ladies Professional Golf Association (KLPGA) tour, 2016 season. The professional golfers participating in each tour directly answered the questionnaires under the supervision of athletic trainers. Via the Yonsei Institute of Sports Science and Exercise Medicine Injury Surveillance System (ISS). **Patients or Other Participants:** A total of 382 professional golfers (age = 22.3 ± 3.3 years, height = 165.5 ± 5.3 cm, weight = 59.7 ± 6.7 kg) participated in the 2016 KLPGA tour. **Assessment of Risk Factors:** The ISS questionnaire contained a total of 35 questions, including female golfer specific information [age, body mass index (BMI), menstrual cycle, golf career, professional career, driving distance, golf practice amount per day, amount of previous season matches etc.]. **Main Outcome Measure(s):** Main outcomes related golf injuries were injury rate during the season, location, mechanism of injury, and possible risk factors of female specific issues. Frequency and chi-square analysis were used to evaluate the golf-related injury. Possible risk factors of female golfer for the injury were analyzed in multivariate analysis using logistic regression. **Results:** Depending on tour level, the injury rate was highest during Division I tour (74.8%), followed by Division II (70.2%) and Division III (66.7%) tour. The most common injury site was the wrist/forearm/elbow (I: 25%, II: 26%, III: 26%), closely followed by the low back (I: 23%, II: 23%, III: 22%). The most common injury mechanism was to occur at the point of ball impact (I: 27%, II: 35%, III: 39%) in the golf swing (I: 57%, II: 57%, III: 56%), followed by the physical training(I: 27%, II: 31%, III: 26%). Multivariate analysis reveal that the BMI (OR=1.173, 95% CI 1.005-1.369), the driving distance (OR=1.122, 95% CI 1.147-8.570) and the amount of previous season matches (OR=2.861, 95% CI 1.312-6.239) were significantly associated with the risk of female golfer specific issues for the injury ($p<.05$). Other factors were not significantly associated with golf injury. **Conclusions:** Common injury sites in golfers are most likely to be in the wrist/forearm/elbow and low back region and injuries tend to occur during golf swing and any contact like the ball impact. Based on statistical analysis, The BMI, driving distance, and amount of previous season matches seem to be significantly associated with the risk factor of female golfer specific issues for the injury. Future studies are required to analyze the epidemiologic patterns of golf injuries by KLPGA seasons.

Comparison of Lower Extremity Range of Motion, Strength, and Power in Collegiate Female Athletes

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Context: The relationships between range of motion, strength, and power have been observed to different capacities in several areas of research. Having a specific ratio of flexibility, strength, and power are important factors in improving athletic performance and injury prevention. **Objective:** To determine if there are relationships between lower extremity range of motion, strength, and power in an attempt to identify an optimal ratio of each for collegiate female athletes. **Design:** Cross sectional cohort **Setting:** Athletic Training Research Lab at a Division I university **Patients or Other Participants:** Twenty-two healthy females (21.23 ± 1.63 years old) collegiate athletes currently on the roster of softball, dance and gymnastics teams. **Interventions:** A goniomter was used to measure hip flexion and hip extension. A hand dynamometer was used to measure hip flexion and hip extension strength. A vertical jump test was used to measure lower extremity power. **Main Outcome Measures:** Variables of interest included hip flexion range of motion (HF ROM), hip extension range of motion (HE ROM), hip flexion strength (HF STR), hip extension strength (HE STR), and vertical jump height. **Results:** Pearson Product Moment correlations were used to determine the correlation between the variables.There was a positive moderate correlation between HF ROM (65.45° ± 23.39) and HE ROM (20.44° ±7.62); r = .470, p = < .05. There was a moderate negative correlation between HF ROM and HF STR (21.45 kg ± 6.39); r = -.498, p < .05. A moderate negative correlation between HF ROM and HE STR (23.88 kg ± 5.70); r = -.440, p < 05. A moderate negative correlation between HE ROM and POWER (34.98 cm ± 6.63); r = -.484, p < .05 and a strong positive correlation between HF STR and HE STR; r = .823, p < .001. **Conclusions:** Regardless of the motion, as the range increased, strength decreased. These results correspond with what was anecdotally observed. Our results suggest that as the hip flexors lengthen there is a decrease in power. The vertical jump test is a plyometric movement which makes use of the stretch-shortening cycle. Considering this principle, long hip flexors place the pelvis in a posteriorly tilted position creating a mechanical disadvantage causing hamstring muscle shortening that may decrease the amount of power generated by the lower extremity, as the hamstrings and gluteal muscle groups have the capability to produce more power than the hip flexor muscles. It is necessary to determine at what range of motion strength deficits occur. By maximizing strength, flexibility, and power output, an athlete can compete at their highest level, while maintaining their safety through proper techniques.

Balance Performance Differs Across Females From Different Physical Activity Concentrations

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Context: Static and dynamic balance assessments have been utilized to identify people at an increased risk of lower extremity injuries. However, there is a lack of normative data from individuals who participate in different forms of physical activity for these tests; particularly in females. It is important to determine if normative data for these tests can be generalized across physically active populations for examining injury risk. **Objective:** Compare performance on the anterior reach of the Y-Balance test (YBT) and modified balance error scoring system (mBESS) across females who participate in collegiate athletics (CA), club sports (CS), spirit squad (SS), and dance studies (DS). **Design:** Cross-sectional. **Setting:** Laboratory. **Patients or Other Participants:** One hundred and forty-six females (Age: 20.21 ± 2.02 years; Height: 163.95 ± 5.76 cm; Mass: 63.45 ± 9.53 kg) who participated in CA (n = 42), CS (n = 37), SS (n = 35), or DS (n = 29) volunteered for the study. All participants were fully participating in their activity and free from current head and lower extremity injuries. **Interventions:** The YBT and mBESS were performed bilaterally while barefoot. Participants completed the anterior reach of the YBT by maintaining balance on the stance limb while maximally reaching with the opposite limb in the anterior direction. Four practice trials were followed by three test trials. Maximum reach distances were normalized to leg length (%). For the mBESS, participants balanced on a single limb for 20s with their eyes closed on firm and foam surfaces. Errors were recorded during the completion of one practice trial and one test trial for each condition. **Main Outcome Measures:** The dependent variables included normalized YBT reach distances, mBESS firm errors, and mBESS foam errors which were averaged and pooled between limbs. A one-way ANOVA

examined group differences for each dependent variable. Post hoc comparisons were completed in the presence of a significant group main effect. Alpha was set a-priori at $p \leq 0.05$. **Results:** There was a significant group main effect for the YBT ($F_{(3,146)} = 5.71$, $p = 0.001$) and the mBESS foam ($F_{(3,146)} = 4.66$, $p = 0.004$) but not the mBESS firm ($F_{(3,146)} = 0.38$, $p = 0.77$). SS members (65.48 ± 5.83%) had greater YBT reach distances compared to CS athletes (59.81 ± 5.88%, $p < 0.001$). Additionally, SS members (6.29 ± 1.37) had fewer errors on the mBESS foam compared to CA (7.36 ± 2.10, $p = 0.05$) and DS (7.56 ± 1.82, $p = 0.02$). No other group differences were identified ($p > 0.05$). **Conclusions:** Females who participated in different forms of physical activity performed differently on static and dynamic balance measures. SS members appeared to have better balance than all other groups while CA and CS athletes had similar balance scores. Therefore, YBT and mBESS normative values and injury risk stratification capabilities may not be generalizable to all physically active females and should be further examined within specific populations.

A Decade of Web-Based Injury Surveillance: The Epidemiology of High School Girls' and College Women's Volleyball, 2004/05-2013/14

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Context: Few studies have reported sport injury incidence across levels of competition. The High School Reporting Information Online system (HS RIO) and the National Collegiate Athletic Association Injury Surveillance Program (NCAA-ISP) are two programs similar enough to make comparisons. **Objective:** To compare a decade of HS RIO and NCAA-ISP injury surveillance data for high school girls' and college women's volleyball. **Design:** Descriptive epidemiology study. **Setting:** Online injury surveillance from an annual average of 100 high schools and 50 NCAA member institutions. **Patients or Other Participants:** Girls'/women's volleyball players that participated in practices and competitions during the 2005/06 - 2013/14 academic years in high school, and the 2004/05 - 2013/14 academic years in college. **Interventions:** Athletic trainers collected time loss injury and exposure data. A time loss injury was defined as an injury occurring during a school-sanctioned practice or competition, requiring medical attention, and resulting in restriction of the athlete's participation for at least 24 hours. **Main Outcome Measures:** Injury rates per 1000 athlete-exposures (AE), Incidence rate ratios (IRRs) with 95% confidence intervals (CI), injury proportions by body site and diagnosis. **Results:** A total of 1634 and 2149 time loss injuries were captured by HS RIO and NCAA-ISP, respectively. These raw data counts represent overall national estimates of 561,709 high school injuries (annual average of 62,412) and 46,449 college injuries (annual average of 4,645). The injury rate was higher in college than high school (3.81 vs. 1.11/1000AE; IRR = 3.43; 95% CI: 3.22-3.66), and in high schools with <1000 students than ≥1000 students (1.33 vs. 0.98/1000AE; IRR = 1.35; 95% CI: 1.23-1.49). At the college level, injury rates did not vary by division (DI: 3.70/1000 AE; DII: 3.94/1000 AE; DIII: 3.87/1000 AE). The injury rate was higher in competitions than practices in high school (IRR = 1.23; 95% CI: 1.12-1.36), but not in college (IRR = 1.01; 95% CI: 0.92-1.10). Ankle sprain was the most common injury in both the high school and collegiate setting, with ranges of 18.4-43.0% of all injuries reported per position. A large proportion of ankle sprains were due to player-to-player contact. However, liberos had a high incidence of concussion (high school: 31.4%; college: 22.9%), many of which were due to contact with the playing surface. **Conclusions:** Injury rates were higher in college than high school. However, variations in injury rates existed by event type in high school, unlike college. Injury patterns in liberos varied from other positions for concussions. Findings highlight the need for injury prevention interventions specific to level of competition and position. For example, to mitigate the incidence of ankle injuries due to player contact, rule changes might prohibit players from stepping on the line under the net. Better skill development related to diving and rolling could also be a focus of injury prevention for liberos.

Free Communications, Rapid Fire Oral Presentations: Concussions Are a Downer: Mental Health After Injury

Thursday, June 29, 2017, 12:15PM-1:15PM, Room 371; Moderator: Rachel Johnson, ATC

A Longitudinal Examination of Perceived Stress and Depressive Symptomology in Concessed and Healthy Collegiate Athletes

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Context: Concussions represent an important public health concern in part for their influence on psychological well-being. Evidence suggests an association between stress, depression, and concussive injuries, thereby validating the need for continued work in this area. **Objective:** To longitudinally examine post-concussion depression and stress in NCAA Division I athletes. **Design:** Descriptive, longitudinal. **Setting:** NCAA Division I athletics. **Patients or Other Participants:** Concussed (n = 12) and sport-matched healthy control (n = 24) student-athletes (18-22 years old) in football, women's soccer, women's volleyball, baseball, women's track and field, or softball. **Interventions:** The Center for Epidemiologic Studies – Depression (CES-D), a reliable (α = 0.82-0.93) self-report depression scale, was completed at baseline, 1 week, 1 month, and 3 months post-concussion. The Perceived Stress Scale–14 (PSS-14, α = .87–.92), used to assess global stress, was completed at baseline, 1 month, and 3 months post-concussion. **Main Outcome Measures:** CES-D and PSS-14 scores represent the sum of a series of Likert scale questions, therefore, parametric statistics were used. Analysis of variance was used to determine if scores were greater in individuals with a history of concussion and if the number of concussions was associated with an increase in these values. Linear mixed models were used to evaluate differences in longitudinal changes in stress and depressive symptoms between groups. Between-group differences in stress and depressive symptoms were assessed via group-by-time interaction. A Pearson correlation coefficient was calculated to examine the relationship between stress and depressive symptoms. Statistical significance was set a priori at α = 0.05. **Results:** Baseline depressive symptom scores between previously concussed participants (8.86 ± 9) and participants with no history of concussion (8.14 ± 11), and baseline stress between previously concussed participants (19.6 ± 10) and those with no history of concussive injury (20.3 ± 19) were not significantly different. Neither stress scores nor depressive symptom scores were associated with the number of previous concussions. Concussed participants reported significantly higher depressive symptom scores one week post-injury compared to baseline, (+7.3, p = 0.001, 95% CI = 2.8, 11.2); scores returned to baseline at 1 month (-6.8) and remained there at 3 months (-8.1). Six of 12 concussed participants (50%) reported at-risk scores for clinical depression at 1 week. Compared to controls, concussed participants' depressive symptom scores were significantly higher 1 week post-injury. There were no significant changes in stress for either group at any assessment point. No association between depressive symptoms and perceived stress was found. **Conclusions:** Athletic trainers should evaluate post-concussion depressive symptoms and maintain a referral plan for at-risk individuals. Although our findings indicated no longitudinal changes in stress, prior research suggests that athletic trainers may want to consider tracking student-athletes' stress levels over the course of their competitive seasons.

Influence of Concussion History on Depression, Anxiety, and Stress in Collegiate Athletes

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Context: Multiple sport concussions (SC) have been demonstrated to be associated with elevated symptom burden, anxiety and depression. The majority of research which has addressed the long-term consequences of one or more SCs has been performed in retired professional athletes with limited research being conducted at the collegiate level of sport. **Objective:** To evaluate the influence of a self-reported concussion history on levels of depression, anxiety, and stress in healthy collegiate student athletes. **Design:** Cross-sectional. **Setting:** Division I university **Patients or Other Participants:** Participants consisted of 153 (92 males, 61 females) varsity collegiate athletes who were approximately 20.2 ± 1.18 years of age. Athletes were recruited from football, volleyball, women's and men's soccer, women's and men's lacrosse, field hockey, and wrestling. Participants were categorized into three groups based off their self-reported concussion history; no concussion (NoCon [n = 88]), one concussion (1Con [n = 49]) and two or more concussions (2 +Con [n = 16]). **Interventions:** All participants completed the Center of Epidemiologic Studies Depression Scale (CES-D), Patient Health Questionnaire-9 (PHQ-9), Hospital Anxiety Depression Scale (HADS), and Perceived Stress Reactivity Scale (PSRS) according to each measure's instructions to assess their depression, anxiety and stress respectfully. **Main Outcome Measures:** Analyses of variance were used to compare CES-D, PHQ-9, HADS, and PSRS outcome scores between groups. Effect sizes were calculated for group comparisons using Cohen's d with 95% confidence intervals. Additionally, subjects in each

group were clinically stratified (e.g. mild, moderate, severe depression) based on the each measure's instructions. Analyses were performed with α = .05. **Results:** No significant differences (p > .05) were observed between groups on depression level (CES-D: NoCon: 8.33 ± 5.54, 1Con: 7.56 ± 6.45, 2+Con: 7.63 ± 5.82 or PHQ-9 NoCon: 3.35 ± 2.93, 1Con: 3.63 ± 3.96, 2+Con: 4.0 ± 3.53), anxiety (HADS: NoCon: 5.0 ± 3.11, 1Con: 5.47 ± 4.13, 2+Con: 6.88 ± 3.44) or stress (PSRS: NoCon: 15.57 ± 7.43, 1Con:15.30 ± 7.94, 2+Con:18.81 ± 6.99). Moderate effect sizes were observed between NoCon and 2+Con groups for the HADS (d = 0.59 (CI: 0.01,1.16)). Approximately 27% of surveyed subjects self-reported clinically significant levels of anxiety regardless of concussion history as indicated by the HADS. Additionally, 23% and 8% of participants self-reported mild and moderate levels of depression as indicated by the PHQ-9, respectively. **Conclusions:** Overall, no significant differences were observed between concussion groups. A moderate effect size was observed for those athletes with 2+ concussions having greater levels of anxiety when compared to those athletes with no history of SC. Regardless of concussion history, approximately 8% to 27% of our sample reported clinically significant levels of anxiety and/or depression as indicated by the respective clinical measure. Our findings support the need for clinicians to incorporate clinical measures of mood state(s) such as the HADS and PHQ-9 into their SC management policy in order to identify at-risk athletes for clinically meaningful levels of anxiety and depression.

The Association of Sport Related Concussions and Symptoms of Depression in High School Athletes

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Context: Sport Related Concussion (SRC) injuries have been associated with an increased risk for short term symptoms of depression in high school athletes. However, there is limited data detailing how a history of sustaining one or more SRC affects levels of depression. **Objective:** To determine the association of a self-reported SRC on levels of depression in healthy high school student-athletes. **Design:** Cross sectional study. **Setting:** Data were collected at 27 high schools at the beginning of the 2016/17 academic year. **Patients or Other Participants:** A convenience sample of N = 1,234 healthy (able to fully participate) high school athletes (448 females, 786 males, age: 15.9 + 1.1 yrs). **Interventions:** Subjects completed a baseline survey (paper, in-person) including a measure of depression severity titled the Patient Health Questionnaire (PHQ-9). The PHQ-9 contains nine questions scored 0-3 (total score range = 0-27). The level of depression severity is scaled as a total score: 0–4 = None, 5-9 = Mild, 10–14 = Moderate, 15–27 = Moderately-Severe. Subjects reported if they had sustained any SRC injuries that caused them to seek medical attention and miss time from their sport and grouped by their history as NoSRC or YesSRC. **Main Outcome Measures:** Dependent variables included the total PHQ-9 scores and distribution of subjects into each level of depression. Analyses included descriptive statistics, the Wilcoxon Rank Sum-Test to compare the total score (median [25th, 75th IQR]) between the subjects in the NoSRC and YesSRC groups and Fischer Exact tests which were used to compare the distribution of the subjects in the NoSRC or YesSRC in each level of depression severity. All analyses were performed with α=.05. **Results:** Nine hundred seventy three (78.8%) self-identified as members of the NoSRC group. A total of n = 261 (n = 79 females (6.4%), n = 182 males (14.7%)) were in the YesSRC group and sustained an average of 1.17 (range: 1–3) SRCs an average of 27.2 + 22.3 months prior to enrollment. No difference was detected (p = 0.36) in the total PHQ-9 score (NoSRC = 0 [0,2], YesSRC = 0 [0,2]). There was no difference (p = 0.41) in the distribution of SRC by depression severity: None (NoSRC = 90.9%, YesSRC = 89.3%), Mild (NoSRC = 6.7%, YesSRC = 8.4%), Moderate (NoSRC = 2.0%, YesSRC = 1.1%) or Moderate-Severe (NoSRC = 0.5%, YesSRC = 1.2%). **Conclusions:** High school athletes who reported a history of SRC did not indicate higher levels of depression compared to their peers who did not sustain a SRC injury. Sports medicine providers need to be aware that the prevalence of depression is similar in athletes with and without a previous SRC.

The Emotions, Coping and Social Support Perceived by NCAA Division I Athletes During Concussion Recovery

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Context: New clinical management of concussed patients require individualized assessment and management plans to improve the outcomes associated with their overall recovery. Numerous pre-injury and post-injury factors such as emotional response, coping strategies, and social support, can affect the recovery process. Understanding the emotional disturbances, coping behaviors, and social support available to concussed athletes may provide valuable information for the healthcare team in management and care for the concussed athlete. **Objective:** Identify and describe the emotions, coping mechanisms and social support perceived by Division I collegiate athletes during recovery from sport concussion. **Design:** Grounded theory, exploratory study **Setting:** Focus groups were conducted in an office in the athletic training facility. **Patients or Other Participants:** Seven Division I males (n = 3) and female (n = 4) collegiate athletes (aged 18-22 years old) sampled on the following criteria participated in the study: history of concussion in previous 2 academic years, sustained concussion during sports competition, full return to learn and participation. **Data Collection and Analysis:** Semi-structured interviews were conducted during two focus group sessions. The focus groups were audio recorded and transcribed verbatim by one of the researchers. The researchers analyzed transcribed notes and evaluated the focus group interviews for themes associated with (1) emotional needs of the collegiate athlete during recovery, (2) coping strategies, and 3) social support received using content analysis. Credibility and trustworthiness was established through member checks. Peer debriefing was utilized to evaluate themes independently and compare results. **Results:** During recovery from concussion, the participants were withheld from sport for a period ranging from 1 week to six months with 71% of the participants reporting a single concussion. Common themes included: 1) participants associated emotions with concussion-related symptoms, 2) participants felt excitement to return to play, 3) participants exhibited maladaptive coping strategies, such as isolation and avoidance during recovery, 4) participants did not seek, but received social support, 5) participants received primary support from families and not University staff, 6) participants perceived overall adequate support and led to better outcomes. **Conclusions:** Following concussion, Division I Collegiate athletes demonstrated maladaptive coping strategies and utilized social support during recovery. While frustration was the primary emotion expressed by the participants, emotions were interchanged with self-report symptoms. Clinicians should encourage athletes to communicate their emotions and provide an active social support network throughout the concussion recovery process. The need for social support in a population where family is not readily available can be amplified with increased stress during injury and/or maladaptive coping strategies enacted following head injuries. It appears that emotions, coping strategies and social support are important factors and future research should be conducted to examine effective interventions focusing on utilizing positive coping strategies and University available social support to improve recovery outcomes.

No Personality Trait Differences Between Collegiate Student-Athletes With and Without a History of Sport-Related Concussion

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Context: Sport-related concussion (SRC) has become a public health at all levels of sport. One strategy to protect against the potential negative consequences related to SRC is to prevent them from occurring through the investigation of injury risk factors. Although many potential risk factors have been studied, there is minimal evidence on how SRC relates to intrinsic psychological variables, such as personality traits. **Objective:** To determine if there are differences in personality traits between collegiate student-athletes with a history of zero (0), one (1), and two or more (2+) previous SRCs. **Design:** Cross-sectional study. **Setting:** Paper/pencil and web-based survey. **Patients or Other Participants:** A total of 1,398 out of 2,055 (68%) collegiate student-athletes from 28 different sports completed the survey. After excluding for age, current SRC, SRC in the past 3-months, current musculoskeletal injury, and non-NCAA athletes there were 1,252 participants remaining. There were 706 (56.4%) male and 546 (43.6%) female NCAA Division-I (n = 327, 26.1%), -II (n = 778, 62.1%), and -III (n = 147, 11.7%) collegiate student-athletes included in this study. The SRC independent variable groups were as follows: 938 (74.9%) participants with 0 previous SRCs, 205 (16.4%) participants who had sustained 1 previous SRC, and 109 (8.7%) participants who had sustained 2+ previous SRCs. **Interventions:** Participants completed a 5-10 minute online survey that included demographic questions, a SRC health history inquiry, and the 44-item Big Five inventory (BFI). The BFI is a commonly used psychological tool to assess broad personality characteristics on a

Likert-scale ranging from 0-5. Institution recruitment occurred via an informative email to head athletic trainers at NCAA colleges and universities in Michigan and Pennsylvania. Subjects were recruited and data was collected during pre-participation examinations and fall season team meetings. **Main Outcome Measures:** The dependent variables were the BFI personality traits, which were extraversion, conscientiousness, neuroticism, openness, and agreeableness. Analysis of Covariance statistics were completed to determine if there were personality trait differences between the 0, 1, and 2+ SRC history groups. Sex and sport type were included as covariates. An alpha level was set a priori at 0.05. **Results:** There were no statistically significant differences between the 0, 1, and 2+ SRC groups for extraversion [$F(1,242) = 2.32$, $p = 0.09$], conscientiousness [$F(1,241) = 0.71$, $p = 0.49$], neuroticism [$F(1,241) = 1.23$, $p = 0.29$], openness [$F(1,241) = 0.76$, $p = 0.47$], or agreeableness [$F(1,242) = 0.00$, $p = 1.0$]. The collegiate student-athlete sample in this study had overall mean BFI personality scores that were high in extraversion (3.53 ± 0.68), conscientiousness (3.8 ± 0.56), openness (3.39 ± 0.51), and agreeableness (3.95 ± 0.54), and low in neuroticism (2.58 ± 0.66). **Conclusions:** There were no differences in personality traits between collegiate student-athletes with and without a history of SRC in this study. These findings indicate that personality traits may not be an important intrinsic risk factor for sustaining a SRC. Future prospective research is needed to strengthen these findings and should incorporate additional intrinsic risk factors.

The Impact of Multiple Sport Related Concussions on the Health Related Quality of Life in High School Athletes

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Context: Athletes who sustain a Sport Related Concussion (SRC) have lower self-reported Health Related Quality of Life (HRQoL) in the weeks following their injury. However, a dearth of research exists addressing the impact of multiple SRCs on HRQoL over several years in active high school athletes. **Objective:** To determine the impact that multiple SCs have on HRQoL in healthy high school athletes. **Design:** Cross sectional study. **Setting:** Data were collected at 27 Wisconsin high schools at the beginning of the 2016/17 academic year. **Patients or Other Participants:** A convenience sample of N = 1,234 healthy (able to fully participate) high school athletes (females n = 448, males n = 786) with an average age of 15.9 + 1.1 years participated in the current study **Interventions:** Subjects completed a baseline survey (paper, in-person) which included the Pediatric Quality of Life 4.0 (PedsQL) to asses HRQoL. Subjects also were asked to their history of medically diagnosed SCs. Subjects were grouped by their number of previous SRCs into three mutually exclusive groups (none [NoSRC], one [1SRC] or two or more [2+SRC]). **Main Outcome Measures:** Dependent variables included the subscale scores (Physical Function [PF] and Psycho-Social Function [PSF]) as well as the total PedsQL score [PedsTS], scored 0 to 100 with a lower score indicating lower HrQoL. Descriptive statistics (mean, range) and frequencies were used to describe the data. Kruskal-Wallis tests were used to compare the (median [25th, 75t IQR]) between the three groups. All differences were assessed with $p < 0.05$. **Results:** A total of n = 973 (78.8%) self-identified as members of the NoSRC group. The YesSRC subjects included n = 142 (17.7%) who reported 1SRC while n = 42 (3.4%) were in the 2+SRC group. Seventy nine (17.7%) females and n = 182 (22.6%) males identified as YesSRC subjects and reported sustaining a total of 307 (mean:1.17 range:1 – 3) SRCs an average of 27.2 + 22.3 months prior to assessment. No significant differences were observed in the PF ($p = 0.15$) scores (none = 100 [93.75, 100], 1SRC = 100 [93.75, 100], 2+SRC+ = 96.88 [87.50, 100]) and the PSF ($p = 0.10$) scores (NoSRC = 95 [88.3, 100], 1SRC = 96.67 [90.0,100], 2+SRC = 92.5 [83.3,98.3]. Finally, no difference was detected ($p = 0.17$) in the PedsTS scores (NoSRC = 95.65 [90.22, 100], 1 SRC = 95.65 [89.13, 100], 2+SRC+ = 93.48 [84.78, 98.91]. **Conclusions:** In this sample of high school athletes there was no differences observed in HRQoL between subjects which varying self-reported histories of SRC. Sports medicine providers should understand that high school athletes who have sustained a SRC several months in the past may not report lower HRQoL.

Age-Related Differences on Initial Post-Concussion Measures and One-Month Quality of Life Outcomes

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Context: Concussions are a growing concern among youth athletes and are often evaluated and treated in primary care clinics, yet few studies have examined age-related differences in concussion presentation in this setting. **Objective:** To examine age differences between initial post-concussion measures and one-month quality of life scores among pediatric concussion patients. **Design:** Prospective cohort study. **Setting:** Primary Care Clinic. **Patients or Other Participants:** A prospective cohort of pediatric and adolescent student-athletes ages 8-18 years, presenting to the primary care setting within 3 days of a sport-related concussion, and consenting to participate in the study (n = 279; age = 14.4 ± 2.1 years). **Interventions:** Participants completed a standardized initial visit, including a clinical exam, symptom checklist, Immediate Post-Concussion and Cognitive Test (ImPACTTM), and near point convergence screening. Athletic Trainers completed data collection at the initial visit. Parents completed a one-month follow-up about their child [Rivermead Post-Concussion Symptom Questionnaire (RPQ), PedsQLTM Quality of Life Inventory (QOL) and the PedsQLTM Multidimensional Fatigue Scale (MDF)]. Age (8-13 vs. 14+) served as the independent variable. **Main Outcome Measures:** Primary outcomes were initial visit scores for: total symptom burden, near point convergence, and ImPACTTM composite verbal memory, visual memory, processing speed, and reaction time. Secondary outcomes were one-month follow-up RPQ persistent symptom presence (3+ symptoms reported as worse than pre-concussion), QOL, and MDF. Independent t-tests were utilized (with mean difference confidence intervals). **Results:** A total of 279 patients met initial inclusion and 180/240 were eligible to complete one-month follow-up and were included in one-month analyses (75 % follow-up). In the total sample, 134 (48.0%) were 8-13 years old; 161 (57.7%) were male; 89 (31.9%) had a previous history of head injury; 21 (7.6%) reported a loss of consciousness post-concussion; and 31 (11.1%) reported amnesia post-concussion. No differences were observed between groups for initial total symptom burden (Mean difference = 1.0; 95% CI: -4.5, 6.5). Initial visit Verbal Memory (Mean difference = 4.2; 95% CI: 0.6, 7.6), Visual Memory (Mean difference = 4.1; 95% CI: 0.9, 8.0), and Processing Speed (Mean difference = 4.7; 95% CI: 2.6, 6.8) were significantly higher in the older age group. Reaction time was not significantly different between older and younger participants (Mean difference = -0.04; 95% CI: -0.08, 0.01). There was also no group difference for initial visit near point convergence score, no association between age group and presence of persistent symptoms, and no differences between groups for quality of life scale scores (QOL and MDF; P > 0.05). **Conclusions:** Age is an important consideration for pediatric concussion patients and is a key factor in clinical decision making acutely post-concussion. These acute age-related differences may not translate to persistent symptom or quality of life differences at one-month post-injury. Clinicians should be mindful that younger individuals may have lower neurocognitive scores on many metrics acutely post-concussion.

The Impact of Concussion on Health-Related Quality of Life as Measured by the Patient Reported Outcome Measures Information Systems in Adolescent Athletes

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Context: Concussive injuries affect multiple health dimensions, suggesting the need for comprehensive assessment that evaluates the whole person from the patients' perspective. Patient Reported Outcomes Measures Information Systems (PROMIS) Pediatric Profile 25 is a commonly used patient-reported outcome measure to evaluate mental and social aspects of health and health-related quality of life (HRQoL). While a multifactorial approach to concussion assessment is suggested, little research has studied the course of recovery of HRQoL following concussion. **Objective:** To assess changes in HRQoL of concussed high school athletes throughout recovery. **Design:** Longitudinal. **Setting:** Athletic training facilities. **Patients or Other Participants:** A convenience sample of 82 interscholastic adolescent athletes (58 males, 9 females,15 missing; age = 15.7 ± 1.0) participating in contact sports, following a medically diagnosed concussion. **Interventions:** Participants were administered the PROMIS Pediatric Profile 25 (5-point Likert scale with 6 subscales; 4 questions per sub-scale) at day 3 (D3), 10 (D10) and return-to-play (RTP). **Main Outcome Measures:** The dependent variables were T-scores for each PROMIS subscale [Physical Function Mobility (PFM), Anxiety (ANX), Depressive Symptoms (DS), Fatigue (FTG), Peer Relationships (PR), and Pain interference (PI)]. Lower PROMIS scores demonstrate better perceived health. Analyses were conducted using generalized estimating equations with a gamma distribution link. Bonferroni adjustment was used for pairwise comparisons (alpha = .05, two tailed). Summary statistics are

reported as means: 95% confidence intervals (CI). **Results:** Significant findings were present for time for the following PROMIS subscales: PFM, ANX, DS, FTG, PR and PI ($p < .001$). Pairwise comparisons revealed higher PFM T-scores at D3 [29.03 (95% CI: 27.58-30.55)] compared to D10 ($p < .001$) [25.64 (95% CI: 23.98-27.43)], and RTP ($p < .001$) [21.77 (95% CI: 20.45-23.18)]. Higher ANX T-scores were found at D3 [44.66 (95% CI: 42.24-47.23)] compared to D10 ($p < .001$) [39.68 (95% CI: 37.29-42.22)] and RTP ($p < .001$) [36.62 (95% CI: 35.36-37.93)]. For the DS subscale, D3 [43.61 (95% CI: 41.79- 45.51)] demonstrated higher T-scores ($p < .05$) than D10 ($p = .009$) [40.99 (95% CI: 38.94-43.15)] and RTP ($p < .001$) [38.44 (95% CI: 37.74-39.15)]. Higher FTG T-scores were found at D3 [52.66 (95% CI: 49.88-55.11)] compared to D10 ($p < .001$) [45.38 (95% CI: 42.42-48.55)] and RTP ($p < .001$) [38.72 (95% CI: 37.11-40.40)]. Further, analyses revealed higher PI T-scores at D3 [52.18 (95% CI: 49.99-54.47)] compared to D10 ($p < .001$) [45.85 (95% CI: 43.15-48.71)] and RTP ($p < .001$) [46.36 (95% CI: 44.65-48.13)], with no difference between D10 and RTP ($p = .76$). The PS subscale T-scores did not differ between D3 [54.41 (95% CI: 52.48-56.41)] and D10 ($p = .91$) [54.56 (95% CI: 51.89-57.37)], but were lower at RTP ($p < .001$) [47.13 (95% CI: 44.78-49.60). **Conclusions:** Concussed student-athletes demonstrated better HRQoL on most PROMIS subscales at RTP when compared to the first days post-injury. These results suggest that HRQoL is immediately hindered following injury, yet improves throughout the recovery process. These findings highlight the need to incorporate PROMs to monitor mental health and social factors that may be affecting the patient post-injury, which may not otherwise be captured without the patients' perspective.

Recurrent Traumatic Knee Effusion in a High School Football Athlete

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Background: A 16 year old high school football player presented to his high school athletic trainer for pain with recurring left knee effusion. Over a two year span, similar effusions had occurred repeatedly while participating in football. Due to repetitive trauma, the athlete had been re-evaluated by his athletic trainer and referred to be seen in the clinic three times previously with similar complaints of pain with excessive edema. During this time, diagnostic testing as well as clinical evaluation took place. Prior MRI had revealed a lobulated suprapatellar mass that was consistent with a hematoma suffered during one of many past traumatic events. The athlete's conditions of pain and swelling were effectively resolved with treatment of ice and compression. At this point, he was cleared and returned to play without recurring symptomology. His most recent event occurred when he forcefully landed on the involved knee in practice. Though able to continue and complete the practice, immediate pain accompanied with mild edema developed in the joint. Worsening pain and swelling developed over the next few days, decreasing his overall knee function and ROM. Upon evaluation, the athlete denied any events of locking or catching in the knee, as well as no instability. There were no other complaints or findings of joint pathology and he denied any episodes of night pain, fever, or chills. **Differential Diagnosis:** Bleeding Disorder, Suprapatellar Bursitis, Lobulated Ganglion Cyst, Pigmented Villonodular Synovitis (PVNS), Meniscal injury, Articular Cartilage injury, Infection. **Treatment:** Evaluation of the left knee by the orthopedic physician revealed a significant effusion with additional soft tissue swelling around the medial suprapatellar region without any significant ecchymosis or erythema. ROM was limited to 0-110°. Diffuse tenderness to palpation over the knee was present. Knee was stable to varus and valgus stress at zero and 30°. No significant laxity with Lachman's or posterior drawer testing. No joint line tenderness. Full ROM of the bilateral hips and ankles without pain. Neurovascular exam intact, distally. The initial few episodes of pain with associated effusion resolved with treatment of NSAIDs, ice and compression. After the most recent episode, swelling continued for about two weeks and the left knee was then aspirated. Upon aspiration, there were 40 cc of bloody fluid drained from the joint. About one week post-aspiration, symptoms had improved significantly, giving the athlete full strength and ROM. At this point, the athlete was referred to orthopaedic oncology to consult doctors for diagnostic and therapeutic arthroscopic removal of the mass found on MRI. Arthroscopic removal of an 8.5 x 6.5 x 2 cm mass and synovectomy was performed with no complications. Results showed benign vascular proliferation with synovitis. **Uniqueness:** While knee injuries frequently occur in the game of football, it's commonly understood that most localized knee effusions are the result of acute cruciate ligament or meniscal pathology. Interestingly, excessive effusion with localized PVNS can occur due to repetitive trauma, though this most commonly occurs in a population of 20-50 year old adults. **Conclusions:** A 16 year old football player with a history of recurring left knee effusion was diagnosed with Pigmented Villonodular Synovitis (PVNS). After further testing, it was decided that the athlete should be referred to orthopaedic oncology. After consultation, an arthroscopy and synovectomy were performed to remove the mass from the knee. Currently, the football athlete has been attending physical therapy for hip and quadriceps range of motion and strengthening. His return to play is based on functional improvement with anticipated return to athletics approximately six weeks post-surgery.

Morel-Lavallee Lesion in Collegiate Softball Athlete

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Background: An 18-year old softball athlete reported to the athletic training facility complaining of right (R) knee pain. The patient reported feeling pain immediately after she slid into third based and her tucked knee was caught on the bag. The AT evaluation revealed minimal pain and no visible swelling, discoloration, or deformities. The patient denied feeling or hearing a snap, crack, or pop. The patient was given ice and was instructed to follow up with AT if symptoms changed. Two days later, the patient reported to the AT with significant swelling. Evaluation revealed TTP on anteromedial soft tissue and medial joint line. Her pain was 5/10 and described as "pinching, dull, throbby and achy" on the outside of her knee. She also reported pain with walking, running, stairs, twisting and squatting. There was decreased AROM on the R leg compared bilaterally. McMurray's, valgus stress test, and varus stress test were negative. The patient denied any mechanical symptoms, numbness, and tingling. She was neurovascularly intact and had no previous history of R knee injury. The patient was removed from all softball activity, instructed to stay immobilized and to rest, ice, compress, and elevate (RICE) until she could follow up with team physician the following morning. **Differential Diagnosis:** Meniscal Tear, ACL Tear, Fracture, Patellar Dislocation. **Treatment:** The patient was examined by the team physician the next morning, and an MRI was ordered due to medial joint line tenderness and swelling on exam. The MRI was significant for a Morel-Lavallee Lesion (MLL) and a normal meniscus. At this time the patient was removed from the immobilization brace, discontinued use of crutches, and began therapy focusing on decreasing swelling, increasing ROM, and pain management.

Her therapy sessions included AROM on stationary bike for 10-minutes, lower extremity stretching, heel slides and quad sets (10 sec hold/5 sec hold ratio) for 20-repititions, and finished therapy with cryotherapy using the cryocuff, elevation, and electrical stimulation for pain management. The patient was also instructed to ice and to work on motion 2-times a day outside of the scheduled therapy sessions. Approximately 7 days post-injury, the patient was able to complete a single-leg hop for distance with a limb symmetry index (LSI) of 93.7%, and 10-repetition max knee extension with 100% LSI. For patient-reported outcomes, 8 days post-injury the patient reported 100% on all domains of the Knee Injury and Osteoarthritis Outcome Score except on the symptoms domain where she scored 67.86% due to some residual swelling. The patient was cleared to return to softball activity due to both functional testing and patient-reported scores. The patient and AT continued to treat her swelling after her return to activity. **Uniqueness:** MLL is an internal degloving injury where the skin and the fascia are separated from the muscle. The literature reports MLLs are typically seen in high impact collision sports, such as football and lacrosse, but rarely occur in low collision sports such as softball. However, the treatment is simple, consisting of cryotherapy and ROM exercises, with most of the evidence suggesting full return to activity within 10-days of injury. More severe cases, which have been previously described as larger fluid collection in the knee, can be treated with aspiration and doxycycline sclerodesis. **Conclusions:** MLL is a rare injury, but can be a potential differential diagnosis for a patient with acute extra-articular swelling of the knee who denies mechanical dysfunction, especially if the patient is involved in a high impact sport. With timely diagnosis and proper therapeutic management, a patient with MLL can return to full activity in a very short period of time.

Ganglion Cyst of the Anterior Cruciate Ligament in a 5-Year-Old Female Gymnast

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Background: A 5-year-old female gymnast presented to our sports medicine clinic with intermittent right knee pain for the past ten days with refusal to bear full weight and obvious limp. The patient and family did not recall any trauma to the knee and her main complaints were pain, several episodes of locking, and inability to reach full knee flexion. Clinical findings of the knee were normal except for limited ROM (0-130°) compared with the uninvolved limb and non-specific medial and lateral tibial plateau tenderness. **Differential Diagnosis:** Bony contusion, stress fracture, internal knee derangement, tendinopathy, inflammatory process, transient synovitis, Legg-Calve-Perthes disease, septic arthritis, infection, neoplasia, and spinal abnormality. **Treatment:** Radiographic findings of the right knee, femur, and bilateral hips were normal. One week of conservative treatment including rest, ice, anti-inflammatories, and non-weightbearing knee immobilization was unsuccessful. An MRI was obtained and revealed hyperintensity within the intracondylar notch between the 2 bands of the anterior cruciate ligament (ACL) compatible with a ganglion cyst. Continued rest and formal physical therapy was prescribed. Symptoms persisted for three weeks, but upon initiation of physical therapy exercises and a home exercise program, the patient's pain spontaneously resolved. At follow up examination the subsequent week, the patient and family stated being symptom-free with full return to gymnastics and other activities; however, repeat MRI was not ordered to see if the cyst had resolved. No reoccurrence of symptoms has been reported at this time. **Uniqueness:** Intra-articular ganglion cysts are relatively rare with an incidence rate described at 0.2% to 1.3% in the literature. In addition, only an estimated 10% of intra-articular ganglion cysts discovered are symptomatic, with many knee ganglia being incidental findings since the advent and increasing use of MRI in the 1990s. Furthermore, ACL ganglion cysts in children are exceptional with only eight previous cases identified in the pediatric population. To date, this is the youngest patient to present with intra-articular ganglion cyst of the ACL, the previous being a 6-year-old male. The method of diagnosis and clinical findings of the 5-year-old gymnast were similar to other reported cases in the literature; however, treatment is controversial. Some orthopaedic surgeons prefer managing symptoms and watchful waiting for spontaneous resolution versus others preferring arthroscopic resection, excision, and debridement to completely remove the ganglion cyst. Our case is atypical because all previous pediatric cases noted in the literature were treated successfully with arthroscopy (with the exception of one open resection case). **Conclusions:** We present the youngest case of ACL ganglion cyst known to date in a 5-year-old female gymnast with no apparent trauma and spontaneous resolution of symptoms. There is substantial argument between congenital and trauma-related pathogenesis of intra-articular ganglion cysts with even less known among pediatric patients. This case adds support to the theory that pathogenesis in children is more congenital and in adults is more trauma-induced. Although exceptional, the intra-articular ganglion cyst should be part of a complete differential diagnosis when faced with non-specific knee pain and possible loss of motion. Athletic trainers are in a unique position to recognize symptoms of knee ganglia and make appropriate referrals when traditional treatments or methods of diagnosis fail to resolve or ascertain a patient's source of pain. Finally, though the literature demonstrates successful treatment of ACL ganglion cyst by arthroscopy, this case suggests that a period of conservative care is warranted, especially in the pediatric population. It can be hypothesized that intra-articular ganglion cysts are under-reported in the literature; those who experience spontaneous resolution likely do not seek advanced medical care and may account for a number of undocumented cases that would otherwise have been treated non-invasively.

Asymptomatic Bucket Handle Tear in a Professional Soccer Athlete

Williams KC, Craddock JC, Felton SD: Florida Gulf Coast University, Fort Myers, FL

Background: Athlete was a 22 year-old (188cm and 83kg) male professional soccer player. Athlete had no previous history of knee injuries. Athlete was evaluated by head athletic trainer immediately following on-field injury. Athlete stated both feet were planted on the ground when he was hit from both the medial and lateral sides of the leg and experienced further contact to his ankle. Initial evaluation revealed no obvious deformities, no swelling of the left knee and moderate swelling over left anterolateral ankle. Athlete was point tender over distal medial collateral ligament (MCL) insertion, medial knee joint line, anterior talofibular ligament (ATF) and deltoid ligaments. Limited knee extension due to pain. Orthopedic clinical examination further included: (+) Valgus test for pain and soft end feel, (-) Varus test, (-) Lachman's, (-) Anterior Drawer, (-) McMurray's test. Ankle special test could not be performed due to pain. **Differential Diagnosis:** Grade I MCL sprain, Proximal tibia contusion, Meniscus tear **Treatment:** As part of the facility's standard of care the athlete was referred to the team physician who ordered images of the injury. Three-view x-rays of left knee revealed no apparent fracture and a well-maintained joint space. Three-view x-ray of left ankle showed a fibular avulsion fracture. Due to the comorbid distal fibular avulsion fracture, athlete began conservative treatment with the athletic training staff for grade I MCL sprain without weight-bearing. After 2 weeks, athlete had no knee pain and no strength deficits of quadriceps or hamstrings. As the rehabilitation for the ankle fracture progressed to weight-bearing, in Week 3, the athlete's knee had minimal to moderate swelling, but athlete complained of no pain. After 6 weeks of ankle rehabilitation, including cutting, lateral movements and jumps, the knee still had full knee range of motion, no pain, but moderate swelling. Athlete was sent back to team physician for final images and to be cleared for training. MRI images revealed a medial meniscus bucket handle tear. At the time of the MRI, the total damage of the meniscus was unknown. It was decided that the athlete would undergo surgery, however, it was unclear whether or not the athlete needed a meniscus repair or a meniscectomy. During surgery, it was revealed that the damage of the meniscus was beyond repair and required a partial meniscectomy. After 4 weeks of rehabilitation with the head athletic trainer, the athlete regained full range of motion and the ability to perform lateral and linear movements. The athlete was cleared by the team physician for functional return to play. **Uniqueness:** Meniscus tears are a common occurring knee injury. Usually, a bucket handle tear presents mechanical symptoms. Commonly, bucket handle tears prevent the knee from going through full range of motion. Patients often describe a locking of the knee. In this case, the placement of the torn meniscus in the intercondylar notch enabled the athlete to still complete full range of motion. This case was unique because the athlete had no presentation of meniscal tear symptoms. The only indication of pathology was knee swelling. Without any range of motion deficits or complaints of pain, it was hard to diagnose a meniscus tear. Furthermore, the initial x-ray did not reveal the pathology. **Conclusions:** This case highlighted the diagnosis of a bucket handle tears with no symptoms using MRI imaging. More importantly, this case demonstrated the significance of recognizing swelling as a sign of pathology to the body's tissues, especially in musculoskeletal injuries such as meniscus tears.

Returning a Division I Hurdler to Sport After Multiple Knee Ligament Injury

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Background: An 18 year old incoming freshman Division I hurdler reported to pre-participation physicals with a history of grade II anterior cruciate ligament sprain, grade II lateral collateral ligament sprain, grade I posterior cruciate ligament sprain, medial meniscocapsular sprain and biceps femoris tendon avulsion suffered in mid-October 2015. The patient underwent posterolateral corner repair in late October and ACL reconstruction in December 2015. The initial interaction between the patient and athletic trainer occurred in June 2016. Initial examination revealed full active and passive knee ROM, approximately 2 inches of atrophy of the right thigh, normal walking and running gait at low intensities, but obvious limp of the right leg during sprinting. Patient displayed minimal apprehension and knee valgus during a drop landing task. **Differential Diagnosis:** Not Applicable **Treatment:** Rehabilitation goals included the restoration of limb symmetry and correct movement patterns and returning the patient to full sport activities in a three month period. In accordance with the demands of hurdling, the patient needed to master single leg landing and eccentric control. The initial four weeks of intervention consisted of two strength days, three agility days, one active recovery day and one rest day each week. Strength sessions consisted of an aerobic warm-up, followed by 10 minutes of Russian electrical stimulation, high volume exercises for the gluteal muscles and quadriceps to develop hypertrophy, and eccentric exercises for the hamstrings. Cardiovascular fitness was addressed in the second half of the session consisting of a running workout, followed by explosive drills focused on movement quality. Agility sessions performed 3 days a week began with exercises to work on hip musculature,30-40 repetitions for each exercise with light loads and concluded with multiple sets

of multidirectional movement for time including sprints, backpedals, lateral shuffles and cariocas. The active recovery day consisted of no more than 20 minutes in duration of a short jog or bike ride at self-selected speeds. During the next four weeks strengthening exercises were reduced in volume and increased in external load and the conditioning was concluded with low intensity hurdling. One agility day was replaced with a plyometric day including double and single limb activities. Conditioning on agility days was replaced with 10-15m sprints to focus on movement during maximal acceleration. In the final four weeks of rehabilitation, the patient was given two days off each week, two strength days, one plyometric day and two days of hill running, stadium stairs and/or sprints of 100 meters or less. The return to play decision included analysis of girth measurements, one-rep max testing of open chain knee extension and flexion and single leg press, the IKDC, single leg hop test, the landing error scoring system and isokinetic strength testing. All measures had to be within 90% of normal or contralateral leg to return to sport. At 3 months this athlete returned to full sport participation. **Uniqueness:** Track and field athletes have a low incidence rate for ACL injuries, creating a unique rehabilitation challenge. Further complicating this rehabilitation is the athlete's hurdling event in which his injured right leg is his landing leg and thereby absorbing the load after each hurdle. Finally, this is a multiple ligament injury so stability of the dynamic stabilizers is critical to account for the rupture of the ACL, LCL and partial tear of the PCL. **Conclusions:** When an athlete reports to an athletic trainer from another healthcare provider it is necessary to fully evaluate their level of function in relation to the demands of their sport. The critical components of returning an athlete to elite level hurdling include a focus on single limb landing and eccentric hamstring strength.

Non-Traumatic Meniscal Cyst in a Collegiate Distance Runner: Clinical Case Report

Thompson AT: Indiana Wesleyan University, Marion, IN

Background: A 22 year old collegiate female cross country runner presented with non-traumatic knee pain after regular training cycles. Upon review, no medical history related to her knees was identified. The patient complained of intermittent stabbing pain during running activity in her right knee. Elevation changes increased the occurrence of the described pain, especially coming off curbs onto pavement or running uphill. Prescribed alternate workouts completed on stationary bikes, elliptical trainers, and ElliptiGO® bikes elicited little to no pain and discomfort. The pain experienced during running activities started at the conclusion of the fall cross country season and progressed in intensity into the spring months. Negative sgns and symptoms were evident via recurrent bouts of minor swelling, point tenderness over the anterior knee along with the medial and lateral joint line of the knee, a "catching" sensations felt/perceived within the joint when running up hills, and an increase in pain when stretching the knee into flexion. Physcial examination found a postive McMurray's test, postiive Thessaly's test and positive Apley's Compression test. **Differential Diagnosis:** Hoffa's Syndrome, patellar femoral syndrome, patellar tendonitis, medial synovial plica, and medial and lateral meniscus tear. **Treatment:** MRI examination identified a medial meniscal tear along with a lateral meniscus tear in the patient knee. However, arthroscopic visualization of the medial and lateral meniscus revealed no discrete tears; a medial meniscus cyst was noted on the anterior part of the meniscus and the lateral meniscus was unremarkable. Treatment of patients involved in distance running with tibofemoral joint cysts in conjunction with acute and/or chronic medical and lateral meniscus tears usually require surgical intervention. Arthroscopic partial meniscectomy of the involved torn meniscus tissue along with meniscal cyst drainage and/ or resection has become the gold standard within the current evidence. The medial meniscal cyst was managed through open cystectomy resection. **Uniqueness:** Meniscal cysts are problematic for distance runners as many non-traumatic benign cysts manifest themselves in a variety of other false-positive pathologies. This case study of a distance runner pursued arthroscopic intervention as a result of being diagnosed with meniscus tears. Conflicting interventions arise from the actual pathology as benign meniscal cysts can be managed through intra-articular drainage and/or open cystectomy resection. Practicing clinicians need to be keenly aware of non-traumatic complaints of knee joint pain diagnosed as meniscal pathology. Preservation of healthy meniscal tissue is of paramount importance in distance runners due to the nature of their training regimen's and performance demands. Collaboration with supervising physicians is imperative to ensure varying interventions are considered before pursuing invasive surgery. **Conclusions:** Open cystectomy drainage could result in permanent removal of the cyst; however, there is the possibility of the cyst reestablishing formation. In cases of benign meniscal cysts, open cystectomy resection of the cyst potentially compromises healthy meniscus tissue and could promote future meniscus fraying and tears. Closed cystectomy drainage assisted through image guided needle insertion could be considered as it is a more conservative treatment and management technique. This intervention could be utilized to create fewer traumas to the knee joint and promote earlier return to activity for distance runners with isolated meniscus cysts. This approach could also reduce the patient's risk of early arthritis, potentially caused by meniscal tissue being resected during an open cystectomy or arthroscopy. Allowing meniscal cartilage to remain uncompromised and choosing to drain benign meniscal cysts with an image guided needle could preserve healthy meniscus tissue.

A Tumor Indicating Fibrodysplasia Found Secondary to an Initial Injury of a Patella Subluxation of the Patients Right Knee

Hart CL, Holloway JP, Porter SE: Newberry High School, Newberry, SC

Background: A 18 year-old male tackle football player (height: 170 cm; weight: 74.8 kg) was going through running back drills during practice, when he cut to the left and his right knee gave out. When the athletic trainer (AT) arrived the athlete was laying supine on the grass field holding his knee. The athlete did not report hearing a pop. Athlete reported of having this same type of injury a few months ago when playing backyard football. Upon palpation the athlete was tender over the entire patella especially the lateral aspect. The athlete did not want to bend his knee or allow the AT to further evaluate his knee after palpation. The athlete was put in a straight leg brace and given crutches. A referral to an orthopedic doctor two days after the initial injury was set up for the athlete. **Differential Diagnosis:** Patella Subluxation, Patella Dislocation, ACL tear. **Treatment:** Initial physician physical exam at the clinic found the athlete had hypermobile patellas bilaterally. An x-ray was ordered to assess for fractures or indication of patella dislocation, noting no significant findings at the knee. Reviewing the x-ray the doctor noted concern to the athlete's fibula. On the x-ray, between the fibula and tibia a white mass showed up like a bone presents on an x-ray next to the fibula. An MRI was scheduled for a week later. The MRI revealed the athlete had a lateral epicondylar fracture and a fracture site underneath where the mass was on his fibula. A CT scan was ordered five days later and the athlete was referred to a orthopaedic oncologist. The athlete was given three options for treatment: 1) continue to monitor by x-ray to see if any growth occurs, 2) begin a chemotherapy treatment to see the effects on the tumor, or 3) take out the mass and biopsy. The athlete chose the last option and a biopsy was scheduled a month after initial evaluation by the oncologist **Uniqueness:** Fibrodysplasia is extremely rare with a worldwide prevalence of approximately one in two million. Fibrodysplasia usually occurs in children ages 3 to 15. However, sometimes it may not be diagnosed until adulthood. Any bone can be affected, but the most common bone involved is the femur followed by the tibia. **Conclusions:** The assessment of musculoskeletal dysfunctions with a high level of suspicion for non-mechanical origins can be a challenge for the clinician examining a sports injury. The symptoms of fibrodysplasia may look like other bone disorders or medical problems. Therefore if known, it is essential to fully understand the role of the inflammatory pathways in triggering flare-ups of the disease, and to better understand the interaction of the immune system with the connective tissue. Without timely diagnosis and treatment of non-mechanical complaints could result in loss of a limb or surgery.

Acute Knee Pain in an Interscholastic Football Player

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Background: A healthy 18 year old interscholastic football player sustained right knee trauma secondary to being struck in the anteromedial aspect by an opponent's helmet. Upon impact, the patient was unable to move. On-field, the patient reported excruciating pain and the knee exhibited a severe posterolateral tibial shift on the femur. Physical examination elicited tibiofemoral tenderness without expanding or pulsatile hematomas or palpable thrills; normal response to lower extremity tactile stimulation; normal tibial and dorsal pedal and pulses; and normal ankle and toe motor function. **Differential Diagnosis:** fracture, collateral sprain, cruciate tear, meniscal tear, posterolateral corner injury, tibiofemoral dislocation **Treatment:** EMS was activated and the AT manually stabilized the knee. While attempting to remove the patient's equipment, the patient reflexively contracted his leg causing the tibia to spontaneously reduce. On-field, the patient was splinted, monitored for neurovascular compromise, iced, and subsequently to the emergency department. In route, EMS administered IV fentanyl for pain. The patient was seen by the attending physician who ordered 2mg IV morphine and lower extremity radiographs which were unremarkable for boney abnormalities. The patient was resplinted and monitored for adequate lower extremity perfusion. After being stabilized, the patient demonstrated normal ankle-brachial index values. He was given crutches and instructed to perform NWB ambulation, referred for follow-up care with an orthopedist, disqualified from all physical activity, and released. Status post 3 days, the patient was seen by the orthopedist who ordered an MRI which revealed severe soft tissue swelling and joint effusion, complete tears of the PCL, MCL, LCL, arcuate ligament, fabellofibular ligament, popliteofibular ligament, biceps femoris tendon, popliteus tendon, and a medial meniscal root avulsion. Given the

complexity of the injury, the patient was referred to and seen by an orthopedic pediatric trauma specialist two days later. Status post 2 weeks, the patient underwent tibiofemoral reconstructive surgery. The patient was placed in a hinged knee immobilizer for six weeks, prescribed analgesics, cryotherapy, and compression, and instructed to ambulate NWB with crutches. Status post 3 weeks, the patient progressed to touchdown weight bearing ambulation and instructed to perform a HEP consisting of ankle pumps, quad sets, and straight leg raises. Status post 8 weeks, the patient demonstrated 60° of knee flexion, was cleared to begin PWB ambulation, and prescribed and completed rehabilitation in an outpatient clinic, supplemented by rehabilitation with the AT on intervening days. Status post 11 months, the patient was discharged from rehabilitation and was able to return to unrestricted recreational activities; however, he was unable to participate at the intercollegiate level. **Uniqueness:** Tibiofemoral dislocations are infrequent and few reliable data exist on its true incidence due to the high occurrence of spontaneous reduction. Additionally, the vast majority of cases result from high-energy trauma associated with industrial or motor vehicle accidents, with only approximately 7% occurring related to sport participation. **Conclusions:** A tibiofemoral dislocation is a complete displacement of the tibia with respect to the femur, with disruption of three or more stabilizing ligaments. Tibiofemoral dislocations carry potential significant complications because of the potential coexistent vascular injury. If missed, a tibiofemoral dislocation has the potential to be limb-threatening. Evidence suggests that the presence of a distal pulse does not rule out the existence of vascular compromise. As such, the use of arteriography is recommended for all cases of tibiofemoral dislocations; however, this case demonstrates that in patients who do not present with definitive vascular insufficiencies (e.g. absent distal pulses, expanding or pulsatile hematomas, or palpable thrills) other forms of non-invasive and less expensive vascular assessment techniques, such as the ankle-brachial index, can be successfully used to monitor vascular integrity.

Simultaneous Bilateral Femoral Stress Reactions in a Healthy Adolescent Female Runner

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Background: A 14-year-old female cross country runner and gymnast was seen in the orthopedic clinic complaining of left groin pain. The pain had an insidious onset and began approximately one month prior to the initial doctor's appointment. The pain increased with running, jumping and back arching activities. An antalgic gait was also noted. A routine physical examination done two months prior revealed no musculoskeletal or physical ailments. **Differential Diagnosis:** Pelvic apophysitis, quadriceps strain, groin strain, labral tear, neoplasm, arthritis, and avascular necrosis. **Treatment:** During the initial orthopedic examination, the physician palpated the anterior inferior iliac spine, pubic symphysis, anterior superior iliac spine, and pelvic crest. The anterior inferior iliac spine and pubic symphysis were tender to palpation. The right hip was pain free throughout full range of motion. The left hip had mild pain with motions past the end range of motion. The athlete had no pain with internal or external rotation or forced hip flexion. However, resisted hip flexion and adduction illicited pain. The fulcrum test and log roll test were both negative. The athlete was unable to bear weight on left leg and unable to hop on left leg without pain. Bilateral radiographs showed no obvious fracture(s). A MRI was ordered to rule out a femoral stress fracture. Results of the MRI showed a left femoral neck stress fracture and a right femoral neck stress reaction. A complete bone health work-up was ordered to determine the cause of these injuries. The dual-energy x-ray absorptiometry scan showed no abnormalities and all values were within normal limits. All values of the complete blood count were within normal limits. The metabolic panel also produced no concerning values. Progesterone and estrogen levels were within normal limits for her age. The athlete was completely non-weight bearing for four weeks and completed physical therapy over the course of three months. Rehabilitation consisted of range of motion exercises, upper body strengthening, and progressive weight bearing activities as tolerated. At ten weeks an Ultra-G treadmill was used to reduce her body weight to start running. Once she could run on 80% of her bodyweight, a gait analysis was completed. The gait analysis revealed a cross-over in her running form. It was recommended she correct the improper form to prevent future injury resulting from long-distance running. **Uniqueness:** Stress fractures are one of the most common injuries in endurance athletes. However, only 8-11% of all stress fractures in athletes and military personnel occur in the femur. Bilateral stress fractures are even more rare. In the past 40 years there have only been 25 reported cases of simultaneous bilateral femoral stress fractures. Most of these cases involved elderly patient population. Only two other cases have been documented in a healthy adolescent female athlete. **Conclusions:** Athletic trainers are in a position to be able to recognize the symptoms and risk factors for femoral stress fractures. Identifying the possible causes of these injuries can be crucial to diagnosing them properly and possibly preventing them. It is important to watch practices and know the tendencies of your athletes in order to identify if they are performing or acting unusual. Informing parents and coaches to encourage athletes to report unusual pain and prolonged pain to the athletic trainer can also help prevent these injuries.

Insidious Onset of a Grade III Femoral Stress Fracture in a Division I Male Cross Country Athlete

Memmini AK, Thompson XD, Johnson LM, Gribble PA: University of Kentucky, Lexington, KY; Charleston Southern University, Charleston, SC

Background: A 20-year-old division I male cross-country runner (height: 1.91m; mass: 56.9kg) presented with increasing right proximal iliotibial (IT) band pain of insidious onset at the beginning of a race week. He was able to walk and run with minimal discomfort and normal gait. Initial evaluation revealed proximal IT band inflammation and a negative Fulcrum test. The athlete was able to complete a light run that afternoon at 40% maximum intensity for 20 minutes with minimal pain. The following day, he reported nonspecific pain throughout his entire lower extremity yet continued to present with normal gait. Two-days post-evaluation, he attempted to jog at 30% maximum intensity and within 5 minutes reported a sharp increase in pain after an unintentional varus knee mechanism. The athlete was removed from activity and referred to the team physician, resulting in negative x-rays. The athlete was placed on crutches, and after two weeks of continued symptoms, an MRI revealed a grade III stress fracture in the right distal femur. **Differential Diagnosis:** Iliotibial band friction syndrome, acetabular labral tear, rupture of the vastus medialis, quadriceps strain, femoral stress fracture, greater trochanter bursitis, patellofemoral pain syndrome. **Treatment:** At initial presentation of sharp pain, the athlete was removed from activity immediately and provided crutches, and was inactive while awaiting x-ray and MRI results. One week after the confirmation of the distal femoral grade III stress fracture, he began isometric quadriceps exercises and general hip strengthening. Four-weeks post-diagnosis, a physician cleared the patient for aqua workouts without lower extremity involvement and limited cycling. For the next five weeks, the athlete was permitted to cross-train by the arm ergometer, underwater treadmill and cycling. By the tenth week, he was cleared for weight-bearing activity including stair-climber, elliptical, and anti-gravity treadmill. In four months total, the patient progressed from limited weight bearing activity, to alternating running surfaces, to clearance for full participation. **Uniqueness:** The literature reports femoral stress fractures to be one of the least common types of stress fractures, specifically in men. Post-puberty women between the ages of 16-25 years are the predominate population to suffer this injury, distance running is the most frequently reported activity/mechanism. Although the probable mechanism of repetitive physical stress of the femur is consistent with the mechanism behind other types of stress fractures, the presentation itself did not follow typical femoral stress fractures during evaluation. Typical symptoms include dull, consistent and nonspecific pain that worsens with weight-bearing activity, in addition to pain for several days to weeks without any improvement. Although the patient meets the criteria for this type of injury mechanism, the timeline of normal gait during the initial evaluation to the inability to weight-bear three days later makes this case unique. **Conclusions:** Although femoral stress fractures are rare, tibial, fibular, and metatarsal stress fractures are amongst the most common reported in distance runners, especially in young females. In compressive stress fractures, conservative treatment with limited weight-bearing and gradual return to participation is often preferred. In other cases, surgical intervention is a necessity. In this case, initial weight-bearing presented with improvement of pain, rather than antalgic gait or inability to run and walk. Athletic trainers should exercise caution athlete presentation of nonspecific pain that has been consistent for several days. In the absence of antalgic gait, criteria for physician referral should include timeline of pain, activity levels, possible mechanisms involved during activity, and specificity of pain.

Free Communications, Poster Presentations: Biomechanical Properties of Head Impacts

George R. Brown Convention Center, Hall C; Tuesday, June 27, 10:00AM-5:00PM; Wednesday, June 28, 10:00AM-5:00PM; Thursday, June 29, 10:00AM-1:00PM

Authors present June 27: Peer Review Authors – Last Names A through M: 10:30AM-11:15AM; Peer Review Authors – Last Names N through Z: 11:15AM-12:00PM

Effects of Protective Headgear on Neurocognitive Function and Injury Risk and Rate in Soccer: A Systematic Review

Forbes CM, Peters NA, Berry DC: Saginaw Valley State University, University Center, MI

Context: Intentional soccer ball heading results in cumulative impact trauma and has prompted manufacturers to develop protective headgear aimed at reducing risk/rate of brain injury and its effects on neurocognitive function. **Objective:** Among soccer players (8-24) does protective headgear compared to no protective headgear effect risk and rate of concussions and neurocognitive function? **Data Sources:** Articles were identified from: PubMed, CINAHL and Medline; using *"Soccer AND Headgear OR Head Gear OR Headband OR Head band AND Concussion*" from January 1996-to-December 2016 (ahead of print), yielding 284 hits. **Study Selection:** Following screening (duplicates, title, abstract), six articles were reviewed. Three met the inclusion criteria: (1) peer-reviewed, observational/experimental studies, (2) available abstract, (3) human studies (4) male/female adolescent and adult athletes, (5) included one key outcome (ie., injury risk/rate, neurocognitive function). **Data Extraction:** Two reviewers independently assessed the studies' level of evidence (LOE) and quality using the Oxford (2011) and Physiotherapy Evidence Database (PEDro) or Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) scales. Data of interest: headgear, injury risk/rate, neurocognitive function/impairment. **Data Synthesis:** Three articles met the inclusion criteria (LOE, 2 = 2, 4 = 1). STROBE scores (n = 2) ranged from 24-27 (maximum score = 32; average = 25.5 ± 2.12); PEDro score (n = 1) was 7/10. All studies measured at least one key outcome: injury risk (n = 2), injury rate (n = 1), and neurocognitive function (n = 1). The Head Injury Criteria (HIC_{36}) revealed no sex headgear (control, Full90 Select, Head Blast) interaction (P = .069, power = .532). Female HIC_{36} scores for the control, Full90 Select and Head Blast groups were 17.5 ± 7.5, 19.7 ± 9.5, 19.5 ± 10.2 respectively and male scores were 15.9 ± 8.2, 13.9 ± 8.0, 16.0 ± 9.1, respectively. Another study of neurocognitive function found that the headgear (Full90) group performed significantly worse on verbal memory baseline (.90 ± .09) to post-test (.85 ± .10, p = 0.03) compared to the control group (no headgear). Additionally, the control group demonstrated significantly faster reaction time baseline (.55 ± .05) to post-test (.52 ± .04, p = 0.03), compared to the headgear group. No significant between group differences for visual memory (p = 0.26), processing speed (p = 0.83) and total symptoms (p = 0.64) were noted. When examining reported concussion-like symptoms, 26.9% of athletes wearing headgear and 52.8% not wearing headgear sustained a concussion. 50.0% and 69% of concussed headgear and no-headgear groups experienced multiple concussions, respectively. Limitations to these studies include: sample sizes, self-reported data, and inconsistent interventions among studies. **Conclusions:** Protective headgear in soccer demonstrates very low-to-low evidence for reducing risk and/or rate of concussions and likely does not mitigate the neurocognitive effects of acute heading. While soccer headgear does not serve its intended purpose, it may protect against soft tissue injury from head-to-head collisions, however, more human research is needed to confirm this hypothesis. Athletic trainers/coaches/parents must weigh the cost of the headgear against it's potential benefit until further human research is conducted.

Comparison of Head Impact Frequency and Magnitude in Collegiate Lacrosse Athletes Between In-Season and Postseason Contests

Soto JA, Bradney DA, Breedlove KM, Bowman TG: Lynchburg College, Lynchburg, VA; University of Delaware, Newark, DE

Context: Head impacts in sport competitions have been linked to the increased risk of traumatic head injuries. Previous studies have shown a significant difference in head impact characteristics based on players' positions, impact locations, and mechanisms. Understanding how the level of intensity changes throughout a lacrosse season could explain head impact magnitude and frequency differences, which could give insight on how to prepare for increased intensities of play to prevent possible head injuries. **Objective:** To examine the relationship between frequency and magnitude of head impacts in male collegiate lacrosse athletes during regular season and postseason contests. **Design:** Descriptive epidemiology. **Setting:** Lacrosse fields. **Patients or Other Participants:** Participants included twenty-nine male collegiate lacrosse players (age = 21.3 ± 0.9 years, height = 179.4 ± 5.6 cm, mass = 80.7 ± 5.9 kg). **Interventions:** Participants wore xPatch sensors by X2 Biosystems during all games throughout the spring 2015 and 2016 seasons. All games were video recorded with a time stamp synced with the sensors to facilitate verification of head impacts. **Main Outcome Measures:** Frequency and magnitude (linear and rotational acceleration) related to head impacts were classified by the event type. The frequencies of head impacts during the regular and postseason were analyzed to find the incidence rates (IRs) per 1000 exposures with corresponding 95% confidence intervals

(CIs). Incidence rate ratios (IRR) with corresponding 95% CIs were found to compare the different event types during the two seasons. Magnitudes (linear and rotational acceleration) were analyzed to determine differences between the 2 event types with Mann Whitney U tests due to violations of normality. **Results:** Participants experienced 482 impacts in 306 regular season game exposures (IR = 1575.16, CI = 1434.54-1715.79) and 206 impacts in 151 postseason game exposures (IR = 1364.24, CI = 1177.94-1550.54; IRR = 1.15, CI = .98-1.36). Event type did not affect linear acceleration (U = 46274.50, P = .16) or rotational acceleration (U = 47679.00, P = .41). **Conclusions:** Considering event type, alone, should not give reason to provide additional preventative measures for male lacrosse athletes. We speculate that an increase in skill level during postseason events may be responsible for the lack of difference in head impact frequency or magnitude between regular and postseason competitions. Future studies should consider other biomechanical factors such as impact location or mechanism between regular and postseason games in an effort to focus preventative interventions.

Differences in Relative Neck Strength and Time to Peak Torque Among Male and Female Division III Soccer Athletes

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Context: Soccer players often use the head to either pass, shoot, or redirect the ball. Increasing neck strength may help reduce head acceleration and increase head-neck segment stabilization when heading. Individuals with smaller head-to-neck circumference ratios tend to have weaker necks and are at an increased risk for sustaining head injuries. Females may fall into this category and have less head mass and neck girth and less head-neck segment stabilization compared to males. **Objective:** The purpose of this study was to determine if a difference exists between male and female soccer athletes in relative neck strength and time to peak torque. **Design:** Non-random, volunteer, independent-groups study. **Setting:** An athletic training clinic at a private college in western Massachusetts. **Patients or Other Participants:** Twenty-eight females and twenty-six males from Division III men's soccer and women's soccer programs from a private college in western Massachusetts volunteered to participate in the study. **Interventions:** Each participant conducted three isometric contractions in four directions (flexion, extension, right and left lateral flexion) against the resistance of a hand-held dynamometer. Neck strength in kilograms and time to peak torque in seconds were measured for each trial. Trials were averaged for each direction and neck strength was divided by the participants' body weight in kilograms to obtain relative neck strength. **Main Outcome Measures:** A MANOVA was calculated for relative neck strength in addition to time to peak torque between the two genders in each of the four neck strength directions. **Results:** No significant difference was found in the mean vectors for males and females for relative neck strength in all four directions (Λ = .889, $F_{(4, 49)}$ = 1.527, p = .209, η_p^2 = .11). When analyzing a univariate ANOVA, a significant difference was found in left lateral flexion relative neck strength, where males had a higher relative neck strength (.168 ± .074) compared to females (.134 ± .042). Differences in right lateral flexion neck strength were not significant (p = .051). For time to peak torque, no significant difference was found in the mean vectors for males and females for relative neck strength in all four directions (Λ = .851, $F_{(4, 49)}$ = 1.527, p = .090, η_p^2 = .15). **Conclusions:** Male and female soccer players did not differ significantly in their relative neck strength or time to peak torque. Left lateral flexion relative neck strength was significantly different and right lateral flexion relative neck strength approached a significant difference which could suggest a better ability among males to attenuate rotary forces during heading. The moderate effect size for relative neck strength and strong effect size for time to peak torque could provide a possible rationale for a higher incidence of concussions among female soccer players when compared to males.

Differences in Regular Season and Postseason Head Impacts of Women's Soccer Athletes

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Context: Subconcussive head impacts have received an increasing level of attention as the concern over brain health has heightened. Determining head impact biomechanics is important in women's soccer to focus prevention initiatives and potentially reduce the risk for head injury and long term sequelae. Studying head impacts in women's soccer is particularly important as women have a higher rate of concussion compared to their male counterparts. It remains unknown if the game type (regular season or postseason) effects the frequency or magnitude of head impacts. **Objective:** To examine the relationship between magnitude and frequency of head impacts during regular season and postseason women's soccer games. **Design:** Descriptive epidemiology study. **Setting:** Collegiate soccer fields. **Patients or Other Participants:** 17 NCAA Division III women's soccer athletes (height = 163.68 ± 4.99 cm, age = 19.88 ± 1.05 years, mass = 61.12 ± 5.00 kg) participated in 19 regular season and 9 postseason games during the Fall 2014 season. **Interventions:** Game type (regular season and postseason) was the independent variable. Participants wore xPatch sensors by X2 biosystems (Seattle, WA). All events were video recorded for impact confirmation. **Main Outcome Measures:** The xPatch sensor collected linear (g) and rotational (deg/sec2) accelerations. We calculated incidence rates (IR) per 1000 exposures and incidence rate ratios (IRRs) with corresponding 95% confidence intervals (CIs) to determine frequency differences. We used Mann-Whitney U tests to determine magnitude differences because we violated normality assumptions. **Results:** During the regular season, participants received almost 1 head impact per exposure (IR = 945.95, CI = 835.15-1056.75). In the postseason, participants received a head impact in approximately 1 out of every 5 exposures (IR = 195.49, CI = 120.35-270.63). Participants were almost 5 times more likely (IRR = 4.83, CI = 3.23-7.23) to get hit in the regular season than when in regular season. Mann-Whitney U tests showed significant differences between postseason and regular season rotational accelerations (U = 2710.00, P = 0.03), with higher rotational accelerations during postseason (mean = 422422.20, SD = 252332.763) than regular season (mean = 317905.57, SD = 199716.408) contests. No significant differences were found between event type for linear accelerations (U = 2876.00, P = 0.07). **Conclusions:** We suspect more impacts occur in regular season games due to potentially lower skill level; however, the rotational accelerations may be higher during postseason games due to an increase in athlete speed and power as the level of competition increases. We recommend educating athletes and coaches on proper heading form and ways to manage head impacts in competition.

Impact Attenuating Capabilities of an American Football Helmet Across a Partial Season of College Football

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Context: American football helmets consist of an inner liner and outer shell both made of polymeric materials aimed at dissipating the energy associated with multiple impacts. These materials are known to degrade over the course of the helmet's service-life. However, peer-reviewed information describing the effect of cumulative service-life upon dynamic head response is scant. **Objective:** Implement a pre- and mid-season safety test protocol to identify potential changes in the capability of an American football helmet to mitigate blunt impact forces. **Design:** A three-way (Time x Position x Velocity) repeated measures ANOVA. **Setting:** Biomechanics research laboratory. **Patients or Other Participants:** Being a helmet experiment, no human subjects were utilized and no demographics are necessitated. A sample of N = 15 helmets (Revolution Speed, Riddell Inc., Elyria, OH) of various sizes (11 Large, 4 Medium) were selected for testing. **Interventions:** At pre- and mid-season, helmets were fit to a medium National Operating Committee on Standards for Athletic Equipment (NOCSAE) headform and were then impacted using a twin-wire drop tower per the standard (ND001-13m15c). Each helmet was impacted at 6 locations (front, side, front boss, rear boss, rear, and top) and 2 impact velocities (11.34 and 17.94 fps). The front and side locations received additional impacts at 13.89 and 16.04 fps, respectively. Linear acceleration data in the three cardinal planes were acquired (sampling rate 20 kHz; CFC 1000 filter) with a triaxial accelerometer mounted in the headform's center of gravity. **Main Outcome Measures:** Mean resultant linear acceleration (peak g) and severity index (SI; the integral

of the resultant x, y, and z acceleration time curves raised to the power of 2.5 over the period of the acceleration time curve) values. **Results:** Over the first 8 weeks of the season, helmets received a mean of 210.1 (±193.0) impacts. Mean resultant peak linear acceleration was 83.1 g (95% CI, 81.3 g - 84.8 g) pre-season and 83.7 g (95% CI, 83.7 g – 84.8 g) post-season. The Time main effect and the Time x Position interaction for peak g were not statistically significant. The mean difference in peak g between pre- and post-season was 1.22 g (95% CI, -0.91 g – 3.4 g). Mean SI was 291.5 (95% CI, 271.4 – 311.6) pre-season and 306.0 (95% CI, 302.3 – 309.7) post-season. The Time x Location interaction for SI was statistically significant ($p < .001$), but not the Time main effect. The mean difference in SI between pre- and post-season was 14.5 (95% CI, -5.1 – 34.1). **Conclusions:** Due to the low number of impacts received between testing periods, our findings were not unexpected. To fully understand if cumulative helmet service-life affects dynamic head response, future work should extend across multiple competitive seasons and reconditioning periods.

Analyzing Magnitude and Frequency of Head Impacts in Relation to Impact Location in Collegiate Soccer Athletes

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Context: Concussions are the most frequent head injury in sporting events and an important factor in long term brain health. Soccer is the most commonly played sport around the world, making it a compelling sport to investigate. Studying the location of head impacts given their frequency and magnitude may provide insight into potential preventative techniques for soccer athletes and valuable knowledge related to head injury prevention. **Objective:** To explore the relationship between magnitude and frequency of head impact locations in collegiate soccer athletes. **Design:** Descriptive epidemiology study. **Setting:** Collegiate soccer fields. **Patients or Other Participants:** 9 Men's (age = 18.67 ± 1.00 years, height = 183.57 ± 5.39 cm, mass = 80.32 ± 13.50 kg) and 19 women's (age = 19.42 ± 1.43 years, height = 166.17 ± 5.24 cm, mass = 64.15 ± 7.23 kg) soccer athletes.Impact location (back, front, side, top) was used as the independent variable. Participants wore xPatch sensors for all games and practices during the fall 2015 season. Each event was video recorded to verify impacts. Sensor threshold was set to 10 g. **Interventions:** Impact location (back, front, side, top) was used as the independent variable. Participants wore xPatch sensors for all games and practices during the fall 2015 season. Each event was video recorded to verify impacts. Sensor threshold was set to 10 g. **Main Outcome Measures:** Sensors collected linear (g) and rotational (deg/s^2) acceleration. We calculated incidence rates (IRs) per 1000 exposures and incidence rate ratios (IRRs) with corresponding 95% confidence intervals (CIs). We violated normality and therefore used Kruskal-Wallis tests to determine magnitude differences and Mann-Whitney U tests for post-hoc testing. **Results:** Based on our results, Division III soccer athletes are likely to experience 2 head impacts every 10 exposures (IR = 214.49, 95% Cl = 186.65-242.33). Participants were 2.33 times more likely to get hit on the side of the head (IR = 113.83, 95% Cl = 93.55-134.11) compared to the front of the head (IR = 48.92, 95% Cl = 35.62-62.21; IRR = 2.33, CI = 1.68-3.22). The effect of the location on linear ($chi^2_3 = 34.23$, $P < .001$) and rotational ($chi^2_3 = 47.31$, $P < .001$) acceleration were both significant. Front impacts were higher than side impacts when analyzing linear accelerations ($U = 1679.00$, $P < .001$) and rotational accelerations ($U = 1315.00$, $P < .001$). **Conclusions:** Impacts to the side of the head may be concerning because concussions are more likely to be associated with impacts to the temporal region. However, head impacts to any location should be limited to avoid concussion and potential long term sequelae. In order to limit head impacts, different coaching emphasis and behavior modifications should be considered. Athletes might be encouraged to reposition their bodies when going up for a header against an opponent in order to protect the side of their head from impact. Further research should investigate if the higher likelihood of a concussion from getting hit on the side of the head is due to anatomical reasons.

Intercollegiate Soccer Athlete Head Impacts Across Field Locations

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Context: Head impact have come under increased scrutiny in recent years as the effects of subconcussive impacts remains not fully understood, especially in soccer athletes. The effect of field location on frequency and magnitude of head impacts in soccer has not been studied. Research concerning sub-concussive impacts may lead to insight on the long term effects of head impacts in men's and women's soccer. **Objective:** To determine the magnitude and frequency of head impacts across field location in intercollegiate soccer athletes. **Design:** Descriptive epidemiology **Setting:** Soccer fields **Patients or Other Participants:** Participants included 9 male (age = 18.67 ± 1.00 years, height: 184.57 ± 5.39 cm; mass: 80.32 ± 13.50 kg) and 17 female (age: 19.42 ± 1.42 years, height: 166.16 ± 5.23 cm; mass: 64.14 ± 7.22 kg) intercollegiate soccer athletes. **Interventions:** Magnitude and frequency of head impacts were recorded via X2 Biosystems xPatch sensors. Sensors were attached to participants behind the right ear on the mastoid process via adhesive patches. All impacts were verified via practice and game film and field location was noted. Field location was divided into offensive and defensive middle, left, right, inside the 18, and inside the 6 zones. **Main Outcome Measures:** The xPatch sensors measured linear (g) and rotational (deg/sec2) acceleration during head impacts. We determined magnitude differences using a Kruskal-Wallis test and Mann-Whitney U tests post hoc due to violations of normality. In addition, we calculated incidence rates (IRs) and incidence rate ratios (IRRs) with corresponding 95% confidence intervals (CIs) to determine frequency differences. **Results:** The magnitude did not depend on field location (Linear: Chi^2_9= 10.29, P = .33; Rotational: Chi^2_9= 14.17, P = .12). The results of the study indicated that a majority of the verified impacts occurred in the defensive zone middle portion of the field (IR = 63.03, CI = 47.94-78.12). Participants were 11 times more likely to get hit in the defensive zone middle compared to the offensive inside the 6 zone (IR = 5.64, CI = 1.13-10.16; IRR = 11.17, CI = 4.84-25.74). **Conclusions:** Set pieces (corner kicks and free kicks) can result in similar magnitude head impacts across different areas of the field. Clearances and goal kicks can often land in the defensive middle zone of the field, which may be a reason why this zone observed the most head impacts. Improved rule enforcement would increase protection for athletes and potentially lower the quantity of sub-concussive impacts. Increased player peripheral awareness would increase protection from impacts from other players, while coaching correct heading technique would lower risk of head injuries resulting from heading the ball.

The Association Between Cervical Neck Strength and Head Impact Biomechanics in Male and Female Adolescent Hockey Players

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Context: Concussions represent a greater proportion of injuries in youth ice hockey than in any other sport. While there is no head acceleration concussion injury threshold, higher magnitude impacts are believed to increase injury risk. Cervical muscle strength has been postulated to mitigate head impact magnitudes, yet previous research yielded mixed results. Additionally, most previous studies focused on college-aged males with little research in females and youth athletes. Identifying factors influencing head impact biomechanics may highlight training and prevention strategies to reduce concussion risk. **Objective:** To determine the association between cervical muscle strength and head impact biomechanics in male and female adolescent hockey players. **Design:** Prospective cohort. **Setting:** Field. **Patients or Other Participants:** Male (n = 47; height = 172 ± 7 cm; mass = 66 ± 10k g; age = 15 ± 1 yrs) and female (n = 38; height = 162 ± 5 cm; mass = 54 ± 11 kg; age = 14 ± 1 yrs) competitive ice hockey players. **Interventions:** Anterior and anterolateral neck flexor, cervical rotator, and posterolateral extensor cervical muscle strength was measured using isometric "break tests" at the start of the competitive season. Participants wore helmets instrumented with the Head Impact Telemetry System (Riddell, Rosemont, IL) to collect linear and rotational accelerations during all games and practices throughout the season. **Main Outcome Measures:** Cervical muscle strength for each muscle group

was divided into weak, moderate, and high strength tertile categories. As males had significantly greater overall normalized neck strength compared to females, the cutoffs for each cervical strength group differed between sexes. Head accelerations were dichotomized into mild (linear: <25g, rotational: <2000rad/s^2) and moderate/severe (linear: ≥25g; rotational: ≥2000 rad/s^2) categories based on a 75th percentile cutoff. Mixed logistic regression analyses estimated the odds of sustaining a moderate/severe impact, controlling for sex, level of play, position, event type, and impact location. **Results:** The odds of sustaining a moderate/severe impact compared to mild impact were higher for players with weak anterior neck flexors (OR: 1.47; 95% CI: 1,09,1.98; $P = 0.04$), weak cervical rotators (OR: 1.51; 95% CI: 1.10, 2.08; $P = 0.04$), weak posterolateral extensors (OR: 1.37; 95% CI: 1.00, 1.88; $P = 0.02$), and moderate posterolateral extensors (OR: 1.49; 95% CI: 1.11, 2.01, $P = 0.02$) than players in the respective high cervical muscle strength categories. There were no significant associations between any of the other cervical muscle strength tertiles and linear acceleration, and none for any muscle group and rotational head accelerations ($P > 0.05$ for all). **Conclusions:** Weak cervical muscle strength was generally associated with increased odds of sustaining moderate/severe linear accelerations, but there was no association between cervical muscle strength and rotational head accelerations. These data suggest that cervical muscle strength may mitigate the magnitude of linear head accelerations, and neck strengthening programs may have an injury prevention benefit. Further research is needed to explore other factors, such as cervical muscle activation rates, bodychecking technique, and closing distance, in hopes of reducing high impact magnitudes and concussion risk.

Pre-landing Lower Extremity Kinematic Patterns Among Chronic Ankle Instability Patients, Ankle Sprain Copers and Healthy Controls

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Context: As a majority of ankle sprains occur during landing and side-cutting, appropriate joint positions prior to high impact landing are critical in reducing risk of ankle injury. Patients with chronic ankle instability (CAI) have shown sensorimotor deficits, which may result in vulnerable joint positions and predispose this injured population to increased risk of ankle reinjury during landing. **Objective:** Compare pre-landing ankle, knee and hip joint kinematics among CAI patients, ankle sprain copers and matched healthy controls. **Design:** Single cohort. **Setting:** Laboratory. **Patients or Other Participants:** 22 CAI patients (M = 12, F = 8; 23 ± 2 yrs, 175 ± 10 cm, 73 ± 12 kg, 82 ± 7% FAAM ADL, 61 ± 12% FAAM Sports, 3.4 ± 1.1 MAII, 4.1 ± 2.8 sprains), 22 copers (M = 12, F = 8; 22 ± 2 yrs, 174 ± 8 cm, 73 ± 12 kg, 100% FAAM ADL, 100% FAAM Sports, 0 MAII, 2.0 ± 1.1 sprains), and 22 matched controls (M = 12, F = 8; 22 ± 2 yrs, 173 ± 8 cm, 69 ± 10 kg, 100% FAAM ADL, 100% FAAM Sports, 0 MAII, 0 sprains) participated in this study. **Interventions:** Subjects performed 5 jumps consisting of a maximal vertical forward jump plus side-cutting at 90 deg while 3D joint kinematics were collected using high-speed video. Spatial trajectories of 59 markers were smoothed using a digital filter (10 Hz). Functional analyses ($\alpha = 0.05$) were used to detect mean differences. If 95% confidence intervals did not overlap zero, significant between-group differences existed. **Main Outcome Measures:** Frontal and sagittal lower extremity joint kinematics from 150ms pre to initial contact. **Results:** The CAI group displayed up to 4.5 deg more dorsiflexion from 150ms pre to initial contact than coper and control groups. Both CAI and coper groups displayed up to 13 deg more knee flexion from 150ms pre to 50ms pre than the control group. Both CAI and coper groups displayed up to 9 deg more hip flexion from 150ms pre to initial contact than the control group. The CAI group displayed up to 3 deg less hip abduction from 150ms pre to initial contact than the coper group. The CAI group displayed up to 1.5 deg more knee adduction from 50ms pre to initial contact than both coper and control groups. **Conclusions:** Relative to coper and control groups, increased dorsiflexion angle across the entire pre-landing phase in the CAI group may be an attempt to avoid self-perceived vulnerable positions of the foot at initial landing as a self-defense mechanism. Moreover, increased knee and hip flexion angle in both CAI and coper groups can be perceived as self-protective positions and have some mechanical advantages of attenuating the high impact loads at initial landing. While kinematic changes in the sagittal-plane are relatively large (up to 11 deg), the changes in the frontal-plane are subtle (less than 2.5 deg).

Ankle Strength Deficits in a Cohort of Collegiate Athletes With Chronic Ankle Instability and Mechanical Laxity

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Context: Context: Lateral ankle sprains commonly occur in an athletic population, with some athletes experiencing recurrent episodes leading to the development of chronic ankle instability (CAI). CAI is a multifactorial diagnosis that may include mechanical and functional instabilities. Mechanical instability is a result of ligamentous laxity, whereas functional instability impacts neuromuscular control. However, the individual contributions mechanical and functional instability have on ankle strength remains unknown. **Objective:** Objective: To compare ankle strength in athletes who have mechanical laxity and self-reported CAI after a history of unilateral ankle sprain. **Design:** Design: Retrospective cohort. **Setting:** Setting: Athletic training research laboratory. **Patients or Other Participants:** Patients or Other Participants: 165 participants including 97 males and 65 females (age = 18.5 ± 0.7 years, height = 178.0 ± 10.3 cm, mass = 78.7 ± 17.1 kg) with history of unilateral ankle sprains. **Interventions:** Interventions: Ankle injury questionnaire and Cumberland Ankle Instability Tool (CAIT) were administered to determine number of previous ankle sprains and presence of self-reported CAI. Mechanical instability was measured using a portable ankle arthrometer including anterior displacement (mm) and inversion rotation (deg.). Isokinetic concentric (CON) and eccentric (ECC) strength was measured at velocities of 30°/sec & 120 °/sec (peak torque [PT]) using a Kin Com dynamometer for plantar flexion [PF],

dorsiflexion [DF], eversion [EV], and inversion [INV] ankle motions. **Main Outcome Measures:** Main Outcome Measures: The independent variable was group status as determined by (1) ankle instability (CAIT scores < or = 25) and (2) ankle laxity (anterior displacement > or = 3 mm and inversion rotation > or = 3 degrees). A hierarchical analysis was performed comparing the dependent variables of PT. **Results:** Results: Twenty-four subjects (14.5%) had both anterior displacement and inversion rotation laxity, while 74 of the 165 participants (44.8%) had self-reported CAI in their injured ankle. When controlling for gender and CAI, the *laxity* group presented with significantly lower PF CON strength at 30°/sec (139.7 ± 43.7 Nm) (t = -2.567, p = .011) and EV CON strength at 120 °/sec (14.8 ± 5.3 Nm) (t=-2.137, p=.034) than the contralateral, uninjured ankle (166.3 ± 56.8 Nm, 17.4 ± 6.2 Nm, respectively). A trend toward significance was seen for ECC PF (194.7 ± 52.4 vs 224.7 ± 82.7 Nm) (t = -1.905, p = .059) and CON PF at 120 °/sec (90.9 ± 32.4 vs 103.0 ± 47.3 Nm) (t = -1.852, p = .066). There were no significant differences in strength between the ankles of those slotted into the ankle instability grouping. **Conclusions:** Conclusion: PF and EV strength deficits are apparent between ankles of those collegiate athletes presenting with mechanical ankle instabilities; and point to the need for clinicians to focus on strength rehabilitation in these individuals. Interestingly, the lack of significant strength differences between ankles in our cohort of CAI athletes provides additional evidence suggesting that the neuromuscular deficits associated with CAI involve other factors instead of strength.

Running Mechanics During 1600-Meter Track Runs in Young Adults With and Without Chronic Ankle Instability

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Context: Chronic ankle instability (CAI) patients have been shown to have altered kinematics and kinetics while running. These findings have been studied extensively in laboratory studies but not in natural running environment. **Objective:** To evaluate running kinematics and kinetics during the loading response using wearable sensors during two 1600m track runs at different speeds between runners with and without CAI. **Design:** Descriptive study. **Setting:** Field. **Patients or Other Participants:** Nine participants with CAI (5 females, 4 males, age = 24.4 ± 5.4 years, idFAI = 21.9 ± 8.5, FAAM-Sport = 71.2 ± 13.7%, previous ankle sprains = 4.9 ± 5.4) and 9 healthy participants with no history of ankle sprain (5 females, 4 males, age = 20.9 ± 4.0 years, idFAI = 0.3 ± 1.0, FAAM-Sport = 99.6 ± 1.3%). **Interventions:** Participants ran 1600m at a self-selected slow pace, defined as running at a rating of perceived exertion (RPE) between 3-4 on a 10-point scale, and 1600m at a self-selected fast pace, defined as an RPE between 5-6, on a competition-grade outdoor track while wearing their own running shoes. Each shoe was fitted with a RunScribe™, a heel-mounted sensor consisting of a triaxial accelerometer and a gyroscope and on-board processing and memory capabilities. **Main Outcome Measures:** Pronation excursion (initial contact to maximum pronation), maximum pronation velocity, peak braking g, and peak impact g measures from each step were collected throughout both runs. Data were binned by calculating means across steps for each measure in 400m increments (Q1, Q2, Q3, Q4). The independent variable were group (CAI, healthy), speed (slow, fast), and distance (Q1-Q4). For each measure, a 2x2x4 ANOVA with Fisher's LSD post hoc tests was performed. The level of significance was set at $P<0.05$. **Results:** Significant group by distance interactions were identified for pronation excursion (P = 0.005), maximum pronation velocity (P = 0.03), braking g (P = 0.01), and impact g (P = 0.01) measures. Regardless of speed, the CAI group (Q1 = 10.5 ± 1.7°, Q2 = 10.1 ± 1.7°, Q3 = 10.2 ± 1.7°, Q4 = 10.0 ± 1.7°) had significantly less pronation excursion across the duration of the runs compared to the control group (Q1 = 13.4 ± 1.7°, Q2 = 14.0 ± 1.7°, Q3 = 14.2 ± 1.7°, Q4 = 14.3 ± 1.7°; LSD = 1.5°). Similar differences were found for maximum pronation velocity, but group differences were significant in only Q2, Q3, and Q4 ((CAI: Q1 = 373 ± 46°/s, Q2 = 366 ± 43°/s, Q3 = 367 ± 41°/s, Q4 = 361 ± 41°/s; Healthy: Q1 = 425 ± 46°/s, Q2 = 454 ± 43°/s, Q3 = 464 ± 41°/s, Q4 = 482 ± 41°/s; LSD = 83°/s). The CAI group had significantly greater impact g's than the control group during Q1 only (CAI: Q1 = 10.4 ± 0.4 g, Q2 = 10.1 ± 0.5 g, Q3 = 10.1 ± 0.5 g, Q4 = 10.0 ± 0.4 g; Healthy: Q1 = 9.4 ± 0.4 g, Q2 = 9.4 ± 0.5 g, Q3 = 9.6 ± 0.5 g, Q4 = 9.9 ± 0.4 g; LSD = 0.9 g). The CAI group had significantly less braking g's than the control group during Q4 only (CAI: Q1 = 9.7 ± 0.4 g, Q2 = 9.3 ± 0.4 g, Q3 = 9.3 ± 0.4 g, Q4 = 9.3 ± 0.4 g; Healthy: Q1 = 9.7 ± 0.4 g, Q2 = 9.6 ± 0.4 g, Q3 = 9.6 ± 0.4 g, Q4 = 9.9 ± 0.4 g; LSD = 0.6 g). No significant group by speed interactions, or group by speed by distance interactions, were observed for any measures. **Conclusions:** Regardless of speed, the CAI group demonstrated altered gait mechanics from the healthy group while running on an outdoor track. The differences identified were not consistent across the entire duration of the 1600m runs.

Examining the Differences in Ligament Laxity Through the Use of an Instrumented Ankle Arthrometer

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Context: The lateral ligamentous complex of the ankle is the most frequently injured structure in athletes who suffer from an ankle sprain. The ligamentous complex surrounding the joint is the primary contributor to the stabilization of the ankle. Determining changes in ligament laxity and alterations to the ligamentous complex after an injury is vital for athletes' recovery. However, differences in ligament laxity between healthy ankles and previously sprained ankles are unclear. **Objective:** To examine the differences in ligament laxity in anterior displacement (AD) and inversion-eversion rotation (IE). **Design:** Cross-sectional study. **Setting:** Motion analysis laboratory. **Patients or Other Participants:** 48 NCAA Division I athletes (24 females, 24 males, age = 20.3 ± 1.6 years, height = 180.8 ± 12.3 cm, mass = 76.5 ± 13.9 kg) were recruited for this study. **Interventions:** Participants who have never sprained their ankles were placed into the healthy group (N = 24) and participants with a history of ankle sprains were placed into the previously sprained group (N = 24). Participants in the previously sprained group were free from injury at the time of testing with a minimum of 6 months since their most recent ankle sprain. Ligament laxities in the AD and IE directions were measured using an instrumented ankle arthrometer (Blue Bay Research Inc., Milton, FL) that quantifies mechanical stress tests, such as anterior drawer and talar tilt. **Main Outcome Measures:** Data were analyzed using an ANOVA to determine the differences in ligament laxity in the AD and IE directions of healthy and previously sprained ankles. **Results:** Ligament laxity in the AD direction was significantly greater in the previously sprained group (7.65 ± 2.76 mm) when compared to the healthy group (6.62 ± 2.03 mm) at P = 0.039. In addition, ligament laxity in the IE direction was also significantly greater in the previously sprained group (37.88 ± 11.42 degrees) when compared to the healthy group (32.81 ± 10.66 degrees) at P = 0.046. **Conclusions:** The results of this study presented a 15% increase in ligament laxity in both the AD and IE directions in athletes with a previously sprained ankle. If the lateral ligamentous complex does not heal properly, mechanical instability may occur and later develop into chronic ankle instability. Improper ligament healing in an abnormal position can lead to deficits in stability. Tissue healing is a complex series of cellular and tissue reactions. Therefore, further investigations are needed to understand the tissue healing process, through the different healing phases, of the lateral ligamentous complex once an ankle injury occurs.

Following Changes in Ligament Laxity Through the Healing Phases After an Ankle Sprain

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Background: Individuals with a previous ankle sprain have reported an increase in ligament laxity. However, it is unknown whether the increase in laxity was present prior to the injury or a result of the injury. Understanding changes in ligament laxity during the healing process of an ankle sprain would aid clinicians during injury rehabilitation. Using an instrumented ankle arthrometer, baseline measurements of anterior displacement (AD) and inversion-eversion rotation (IE) of each ankle were taken from NCAA Division I athletes during preseason. If an athlete sprained their ankle, additional AD and IE measurements were taken within 24 hours, 3 days, 3 weeks, and 5 weeks post-injury. To date, six athletes have suffered a sprained ankle: two from men's basketball, two from women's basketball, and two from men's soccer (age = 19.9 ± 1.3 years, height = 188.5 ± 7.3 cm, mass = 84.5 ± 6.7 kg). **Treatment:** All ankle sprains received the standard of care by a certified athletic trainer. Athletes returned to play within 24 hours with external supports of ankle taping or bracing. Treatments using modalities and rehabilitative exercises were continued for each of the injured athletes. The uniqueness is not in the treatment of these athletes, but in the availability of the data highlighting changes in ligament laxity following an ankle sprain in various time points of the healing process. In addition, having the preseason measurement allows for the comparison of post-injury measurements to a pre-injury baseline measurement. **Results:** The baseline measurement of ligament laxity in the AD direction was 8.00 ± 3.87 mm. The following are post-injury measurements: 24 hours = 7.55 ± 1.18 mm, 3 days = 8.24 ± 0.89 mm, 3 weeks = 8.07 ± 0.71 mm, and 5 weeks = 7.50 ± 0.80 mm. The baseline measurement of ligament laxity of IE rotation was 25.79 ± 9.29 degrees. The following are post-injury measurements:

24 hours = 24.53 ± 6.91 degrees, 3 days = 31.03 ± 13.62 degrees, 3 weeks = 30.52 ± 9.58 degrees, and 5 weeks = 24.35 ± 8.49 degrees. **Uniqueness:** Being able to compare alterations in ligament laxity to a baseline measurement has never been reported. This study provides data on the changes in ligament laxities as a result of ankle sprains through the acute inflammatory, repair, and remodeling phases with a comparison to pre-injury measurements. Understanding adaptations of tissue extensibility through the phases of healing after an injury will give clinicians even more insight to proper rehabilitative progressions. **Conclusions:** With a low sample size, a statistical analysis cannot be use to quantify these changes. However, inferences can be made to the trends seen in these subjects. In the acute phase of injury, within 24 hours, there is an initial decrease in ligament laxity of the ankle joint. This increase in joint stiffness could be on account of the increased tension in the musculature surrounding the ankle joint. The increase in tension may have been caused by the trauma experienced at the ankle. Conversely, during the repair phase at 3 days and 3 weeks post-injury, the data shows an increase in ligament laxity. Perhaps, the acute reactions of the soft tissue to the trauma around the ankle have subsided and the damage to the ligaments is now presented in the ankle arthrometer measurements. Finally, the 5-week time period that is associated with the beginning of the remodeling phase seems to display ligament laxity measurements returning to the pre-injury baseline. These data marks the beginning of a longitudinal study. We plan to follow-up with these injuries at a 6-month time period. Understanding changes within ligaments throughout the healing phases of an injury can help clinicians provide optimum care for athletes. Further, as this study continues, a larger subject pool would provide a better insight to the healing process of the ligaments after an ankle sprain.

The Influence of Hip Strength on Landing Kinematics in Individuals With Chronic Ankle Instability

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Context: Individuals with chronic ankle instability (CAI) often exhibit reduced posterolateral hip muscular strength. Hip joint positioning influences foot placement during functional movement, and a more adducted, externally rotated hip may increase propensity for recurrent lateral ankle sprains (LAS). However, it remains unknown how hip muscular strength deficits influence proximal landing mechanics in those with and without CAI. **Objective:** Compare differences in hip muscular strength and frontal and transverse plane kinematics between those with and without CAI, and determine the amount of kinematic variance explained by hip muscular strength. **Design:** Single-blinded case control study. **Setting:** Research laboratory. **Patients or Other Participants:** Seventy-six members of the university community volunteered, and were separated into CAI (22 F, 4 M; 24.2 ± 4.0 yrs; 167.2 ± 7.3 cm; 73.5 ± 14.9 kg), LAS-Coper (19 F, 6 M; 24.0 ± 5.2 yrs; 166.7 ± 8.8 cm; 69.5 ± 17.1 kg), and Control groups (14 F, 11 M; 23.0 ± 3.6 yrs; 168.7 ± 7.6 cm; 69.1 ± 13.6 kg). **Interventions:** Participants performed 5 vertical jumps (50% of maximum) with single-leg landings. Kinematics were collected with 10 high-speed cameras, 56 retroreflective markers and 3D motion capture software. Participants completed three 5-second trials of isometric hip extension (EXT), abduction (ABD), and external rotation (ER) strength using a hand-held dynamometer. CAI and LAS-Coper groups were tested on the involved limb, and Controls were tested on a randomly-selected limb. **Main Outcome Measures:** Frontal and transverse plane hip kinematics were collected from 200ms pre-initial contact (IC) to 50ms post-IC. Peak torque (N) from strength testing was averaged, multiplied by moment arm length (m) and divided by body mass (kg) to obtain normalized torque (Nm/kg). Separate one-way ANOVAs assessed group differences in 3D hip kinematics at every millisecond within the selected time interval. Separate one-way ANOVAs and Cohen's *d* effect sizes assessed group differences in hip strength. Separate backward linear regression models determined the contribution of hip strength to hip kinematics at every millisecond for each group. Significance was set *a priori* at $P < 0.05$. **Results:** The CAI group exhibited less hip abduction than LAS-Copers for the entire time interval ($P = 0.01$) and Controls from 109ms pre-IC to 50ms post-IC (P-value range = 0.01-0.05), and less hip external rotation than Controls from 67ms pre-IC to 4ms pre-IC ($P = 0.01$). The CAI group had significantly lower ER ($P = 0.01$) than LAS-Copers ($P = 0.04$, $d = 0.62$ [0.05,1.17]) and Controls ($P < 0.01$, $d = 0.87$ [0.28,1.43]). ER explained a significant amount of frontal plane hip angle variance in LAS-Copers from 31ms pre-IC to 50ms post-IC (R^2 range = 0.15,0.18; P-value range = 0.03-0.05). Hip strength was not associated with frontal or transverse plane hip kinematics in CAI and control groups. **Conclusions:** Compared to LAS-Copers and Controls, those with CAI displayed altered frontal and transverse plane hip kinematics, which may increase propensity for medial foot placement and external supination moments. Although the CAI group displayed decreased hip muscular strength, increasing isometric hip strength is likely not an effective means of correcting hip movement patterns in this population.

Effects of Prophylactic Ankle Bracing/Taping Compared to Balance Training in Reducing the Incidence of Acute Lateral Ankle Sprains in Adolescent Athletes: A Systematic Review

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Context: External supports (ie., bracing and taping) and balance training (BT) programs are believed to reduce the risk of ankle injuries in active individuals. **Objective:** Systematically review, evaluate and summarize the literature to determine whether external supports and/or BT programs significantly reduce the risk of acute ankle injuries among adolescent athletes. **Data Sources:** Relevant articles were identified from Pubmed from January 2000 through October 2016 using three search phrases: (1) *"Ankle Injuries/ epidemiology"[MESH] AND Ankle AND (Taping OR Tape OR Brace or Bracing OR Prophylactic OR Balance OR Coordination)*, (2) "Prevention AND "ankle sprain" AND balance" and (3) *"Sprains and strains/prevention and control" [MESH]AND ankle AND (taping or tape or brace or bracing or prophylactic or balance or coordination)* resulting in 146 articles. **Study Selection:** After title and abstract screening, 23 articles were selected for possible inclusion. Five articles were included in this review using the following inclusion criteria:(1) randomized clinical trial (RCT), controlled clinical trial without randomization, prospective and cohort studies, (2) English language, (3) available abstract, (4) utilized healthy adolescents without a history of ankle sprains, aged 13-25, (5) outcomes measuring risk, rate and/or severity of acute ankle injuries. **Data Extraction:** Three reviewers independently assessed the studies' level of evidence (LOE) and quality using the Oxford, Physiotherapy Evidence Database (PEDro) and STrengthening the Reporting of OBservational studies in Epidemiology (STROBE) scales, respectively. Data of interest: subjects; interventions; descriptive data, Cox Hazard Ratio (HR), risk ratio (RR) and 95% confidence intervals (CI). **Data Synthesis:** Five studies (LOE 1a = 4, 2b = 1) met the inclusion criteria. PEDro scores (n = 4) ranged from 4-7 (maximum score = 10; 5.58 ± 0.64), while the STROBE score for one article was 13 (maximum score = 22). Pooled sample size was 5,689 with a mean age of 16.5 ± 1.1 (range = 14-18). Two studies examined rate of ankle injuries per 1,000 exposures with/without ankle bracing, finding a reduction in the incident rate, but not injury severity, (HR = 0.39; 95% CI: 0.24-0.65; $P < 0.001$) in football and (HR = 0.32; 95% CI: 0.20-0.52; $P < 0.001$) in basketball players. Athletes participating in a BT program demonstrated a decreased risk of ankle injury (RR = 0.56). The rate of ankle sprains was significantly lower in the BT group compared to the control group (6.1%, 1.3 per 1,000 exposures vs. 9.9%, 1.87 of 1,000 exposures; $P = 0.04$). An additional study found BT programs also reduce injury risk (RR = 0.71; 95% CI: 0.5-0.99). Bracing protected volleyball players from injury when no previous ankle sprains ($p < 0.05$) were reported. **Conclusions:** Results suggest a decrease in the risk of acute ankle injuries among adolescent athletes participating in prophylactic ankle bracing/taping or BT program. Using prophylactic external supports may reduce the risk of injury, but are often associated with increased cost and time; whereas BT is more cost and time effective.

Increased Hip Strength Following a 4-Week Comprehensive Ankle Rehabilitation Program in Persons With Chronic Ankle Instability

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Context: Chronic ankle instability (CAI) is a complex condition associated with a myriad of impairments throughout the lower extremity. Rehabilitation programs which included balance training, strength training, and manual therapies have successfully addressed many of the impairments local to the ankle. However, people with CAI have also demonstrated hip muscle weakness which may promote altered movement patterns and re-injury mechanisms. Currently, it is unclear if hip strength can be improved through the evidence-based interventions previously developed for CAI. **Objective:** Determine if a 4-week comprehensive ankle rehabilitation program can improve hip strength in individuals with CAI. **Design:** Interrupted time-series. **Setting:** Laboratory. **Patients or Other Participants:** Twenty adults (15 females; age = 24.4 ± 7.0 years; height = 169.29 ± 10.1 cm; weight = 70.6 ± 12.9 kg) with self-reported CAI participated. Inclusion criteria consisted of a history of ≥1 ankle sprain, ≥2 episodes of giving way in the past three months, answering "yes" to ≥4 questions of Ankle Instability Instrument, and scoring ≤24 on the Cumberland Ankle Instability Tool. **Interventions:** All subjects participated in a 4-week intervention which included dynamic balance training, ankle strengthening exercises, and talocrural joint mobilizations during twelve sessions with an athletic trainer. Subjects were also instructed to perform daily gastroc-soleus complex stretching and ankle strengthening exercises at home throughout the four weeks. Isometric hip abduction, adduction, flexion, and extension strength were assessed using a handheld dynamometer.

Peak forces were recorded to the nearest 0.1N. Hip strength was measured four weeks before the intervention (baseline), prior to the first intervention session (pre-intervention), 24 hours following the final intervention session (post-intervention), and two weeks following the intervention (follow-up). For each measure, three trials were collected and averaged during each data collection session and used for analysis. **Main Outcome Measures:** The independent variable was time (baseline, pre-intervention, postintervention, follow-up). The dependent variables were peak isometric strength for hip abduction, adduction, flexion, and extension normalized to body mass (N/kg). Minimal detectable change (MDC) was assessed using baseline and pre-intervention data. Separate repeated-measures ANOVAs examined differences over time (pre-intervention, post-intervention, follow-up). Bonferroni post hoc comparisons were completed in the presence of main effects. Alpha was set *a-prior* at $p \leq 0.05$. **Results:** MDC values for hip abduction, adduction, flexion, and extension were 0.177, 0.168, 0.179, and 0.199N/kg, respectively. A significant main effect was detected for abduction ($p = 0.002$), adduction ($p < 0.001$), flexion ($p = 0.03$), and extension ($p < 0.001$). Significant increases were identified at post-intervention ($p \leq 0.03$) and follow-up ($p \leq 0.002$) for all measures except post-intervention abduction ($p = 0.12$) and follow-up flexion ($p = 0.15$). Most change scores improved beyond the MDC values for each measure. **Conclusions:** A 4-week comprehensive ankle rehabilitation program increased hip strength in individuals with CAI. These findings suggest the current evidence-based rehabilitation strategies for CAI may have widespread benefits for lower extremity function despite targeting common ankle impairments.

Effect of Six Weeks Rehabilitation on Ankle Neuromechanic Patterns in Subjects With Chronic Ankle Instability

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Context: Sensorimotor deficits due to lateral ankle sprains can result in altered mechanics in the lower extremity. The ankle and hip have been an area of focus in this patient population, however little is known about interventions specific to these areas. **Objective:** To investigate the effect of a six-week ankle and hip intervention program on ankle muscle activity and biomechanical patterns during a forward-side jump in patients with CAI. **Design:** Single cohort, descriptive. **Setting:** Controlled, laboratory. **Patients or Other Participants:** 15 CAI subjects in a rehab group (23 ± 2 yrs, 178 ± 8 cm, 76 ± 9 kg, 83 ± 7% FAAM ADL, 56 ± 10% FAAM Sports, 3.6 ± 1.1 MAII, 4.7 ± 2.0 ankle sprains), and 14 matched CAI control subjects (22 ± 2 yrs, 177 ± 9 cm, 75 ± 12 kg, 81 ± 9% FAAM ADL, 56 ± 12% FAAM Sports, 5.9 ± 3.3 sprains) participated in this study. **Interventions:** 15 CAI subjects in a rehab group completed a series of 10 ankle and hip strength and proprioceptive exercises (theraband, wobble board, ankle disk, etc.) 3 times/week for 6 weeks under supervision. Subjects were tested on the dominant limb with three sEMG electrodes, and fifty-nine reflective markers were place over anatomical landmarks to calculate joint angles and moments as well as muscle activation. Subjects performed five trials of a forward-side jump before and after a six-week rehabilitation intervention. Functional linear models ($\alpha = 0.05$) were used to evaluate group by treatment interactions over time. Functions (curves) were compared between groups across conditions (pre- vs post-rehab). Pairwise comparison functions as well as 95% confidence interval (CI) bands were plotted to determine specific differences. If 95% CI bands did not cross the zero line, we considered the difference significant. **Main Outcome Measures:** Joint angles (°), moments (N·m/kg), and EMG amplitude (%) were measured from initial foot contact (0%) to take-off (100%). **Results:** The rehab intervention resulted in up to 3° greater plantarflexion angle at 8-12% of stance, 2° less inversion angle at 85-100%, 0.2 Nm/kg less plantarflexion moment at 0-10% and 85-100% of stance, and 0.1 Nm/kg greater eversion moment at 5-85% of stance. Relative to control group, the rehab group increased peroneus longus activation between 20-40% of stance and decreased medial gastrocnemius activation between 15-25% of stance. **Conclusions:** Following a 6-week rehabilitation program, CAI patients demonstrated altered ankle neuromechanic patterns in a way that increased eversion; likely a result of increased eversion moment and peroneus longus activation. CAI patients in the rehab group decreased plantarflexion moment and medial gastrocnemius activation with greater plantarflexion angle in the initial phase of landing. More data are needed to link these findings to injury risk.

Decreased Injury-Related Fear Following a 4-Week Comprehensive Intervention for Those with Chronic Ankle Instability

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Context: Individuals with chronic ankle instability (CAI) suffer from functional and self-perceived impairments. Established CAI interventions have proven effective at improving many functional and ankle-specific complaints. However, injury-related fear has yet to be investigated following rehabilitation for those with CAI. CAI is associated with increased levels of injury-related fear that may limit physical activity levels and put individuals at risk for chronic diseases. **Objective:** Determine if a 4-week comprehensive rehabilitation program can decrease injury-related fear in those with CAI. **Design:** Interrupted time-series. **Setting:** Laboratory. **Patients or Other Participants:** Twenty physically active adults (15 females; age = 24.4 ± 7.0 years; height = 169.29 ± 10.1 cm; weight = 70.6 ± 12.9 kg) with self-reported CAI participated. Inclusion criteria consisted of a history of ≥1 ankle sprain, ≥2 episodes of giving way in the past three months, answering "yes" to ≥4 questions of Ankle Instability Instrument, scoring ≤24 on the Cumberland Ankle Instability Tool. **Interventions:** Subjects participated in 12 intervention sessions in which they completed balance training, ankle strengthening, and talocrural joint mobilizations over the course of four weeks. Additionally, subjects were instructed to perform daily home ankle strengthening and gastroc-soleus complex stretching exercises throughout the four weeks. Injury-related fear was assessed using the Fear Avoidance Beliefs Questionnaire (FABQ). The FABQ is comprised of two subscales that assessed injury-related fear during physical activity (PA) and work (W) activities. The 5 items of the FABQ-PA and 11 items of the FABQ-W are each scored on a 7-point Likert scale. Greater scores on the FABQ indicate increased injury-related fear. The FABQ was measured four weeks before intervention (baseline), prior to the first intervention session (pre-intervention), 24-48 hours following intervention cessation (post-intervention), and two weeks following intervention cessation (follow-up). **Main Outcome Measures:** The independent variable was time (baseline, pre-intervention, post-intervention, and follow-up) and dependent variables were FABQ-PA and FABQ-W scores. Cronbach's α and standard error of measurement were used to calculate minimal detectable change using the baseline and pre-intervention data. Separate repeated-measures ANOVAs examined differences in each dependent variable over time (pre-intervention, post-intervention, follow-up). Sidak post hoc comparisons were completed in the presence of significant main effects. Alpha was set *a-priori* at $p \leq 0.05$. **Results:** Minimal detectable change (MDC) values for FABQ-PA and FABQ-W were 3.18 and 5.39 respectively. A significant main effect was identified for the FABQ-PA ($p < 0.001$). Post hoc analysis identified significant reductions at post-intervention ($p < 0.001$, 6.50 ± 5.01) and follow-up ($p < 0.001$, 5.65 ± 4.74) compared to pre-intervention (12.60 ± 4.22) for the FABQ-PA. A significant time main effect was not identified for the FABQ-W ($p = 0.16$). **Conclusions:** The 4-week comprehensive rehabilitation program significantly reduced injury-related fear in those with CAI. Changes in post-intervention and follow-up scores surpassed the MDC associated with the FABQ-PA. These findings suggest that clinically relevant changes in injury-related fear occurred and persisted after the cessation of the intervention.

The Relationship Between Foot Posture, Dorsiflexion Range of Motion and Lower Extremity Biomechanics During a Drop-Landing Task

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Context: Foot posture and dorsiflexion range of motion (DROM) deficits have been linked to lower extremity injuries. It is unknown whether these variables at the foot and ankle influence lower extremity biomechanics during functional activity. **Objective:** Examine the relationship between foot posture, DROM, and lower extremity biomechanics during drop-landing. **Design:** Cross-sectional. **Setting:** Laboratory. **Patients or Other Participants:** Fifteen physically active adults (9 females, 6 males, age: 22.6 ± 2.4 years, height: 1.69 ± 0.07 m, mass: 66.40 ± 9.95 kg) volunteered to participate. Participants were excluded if they reported a history of lower extremity injury within 6 weeks or lower extremity surgery. **Interventions:** Participants completed a single testing session that included static foot posture assessment, weight-bearing DROM evaluation, and a biomechanical analysis of a drop-landing task on the dominant limb. The six criteria of the Foot Posture Index (FPI-6) evaluated foot posture and the total score was used for analysis (-12 to +12). The weight bearing lunge test assessed weight-bearing DROM using the knee-to-wall principle in which the maximum lunge distance was measured in centimeters. Three trials were collected and averaged for analysis. Sagittal and frontal plane kinematics and kinetics of the hip, knee, and ankle were captured using a 3D motion capture system and forceplate during three successful trials of a drop-landing task. Box height was set to maximal vertical jump height for each participant. **Main Outcome Measures:** The dependent variables included, total FPI-6 score, average DROM, and average hip, knee, and ankle sagittal and frontal plane kinematics and kinetics. Kinematics were reported at initial contact and total excursion (°). Maximal internal joint moments were normalized to body mass (N/kg). Pearson correlations (r) along with coefficient of determination (r^2) were performed between the FPI-6, DROM, and individual kinematic and kinetic variables. In cases where both FPI-6 and DROM significantly correlated to a biomechanical variable, multivariate linear regression was used to model the relationship. Significance was set at $p \leq 0.05$ for all analyses. **Results:** FPI-6 scores (4.67 ± 2.94) were significantly correlated with knee abduction angle at initial contact (1.08 ± 3.30°, r = -0.59, r^2 = 0.35, p = 0.021), ankle sagittal plane excursion (39.11 ± 7.67°, r = -0.63, r^2 = 0.39, p = 0.013) and knee adduction moment (0.58 ± 0.51 N/kg, r = 0.60, r^2 = 0.36 p = 0.017). DROM significantly correlated with knee adduction moment (r = -0.59, r^2 = 0.35, p = 0.020). The combination of FPI-6 and DROM accounted for 56% of the variance in knee adduction moment (r = 0.746, p = 0.008). No statistically significantly relationships were identified for hip variables ($p > 0.05$). **Conclusions:** Participants with a more pronated foot posture displayed less knee adduction angle at initial contact and decreased ankle sagittal plane excursion. Those with less DROM and a pronated foot posture exhibited increased maximum knee adduction moment indicating an increase in valgus knee loading. Collectively, these findings provide evidence that the structure of the foot and ankle can significantly influence lower extremity biomechanics.

The Effects of Athletic Floor Surfaces on Lower Extremity Kinematics During Cutting and Drop Vertical Jump Performance in Female Athletes

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Context: The sports surface-athlete interface should be considered with respect to the biomechanical etiology of injury. Commercially available athletic flooring manufacturers have proposed decreased ground reaction forces without compromising vertical jump performance. To assess lower extremity kinematics in female athletes performing sport-specific movements (drop vertical jump and cut) on two athletic flooring surfaces: SmartcellsÒ [SM] and Sport CourtÒ [SP], as compared with a control [CO] surface. **Objective:** To assess lower extremity kinematics in female athletes performing sport-specific movements (drop vertical jump and cut) on two athletic flooring surfaces: SmartcellsÒ [SM] and Sport CourtÒ [SP], as compared with a control [CO] surface. **Design:** Randomized Crossover Trial. **Setting:** Research Laboratory. **Patients or Other Participants:** Sixteen healthy division II female volleyball athletes (age 20 ± 1.3 yrs; height 175.8 ± 7.3 cm; weight 71.5±7.1 kg) provided informed consent to participate in the study. **Interventions:** After providing informed consent, participants were instrumented with a standard lower extremity plug-in-gait marker set, after which lower extremity kinematics were tracked during performance of two movement types (drop vertical jump and 45 degree cut) on each surface using a 6-camera motion capture system (Vicon, Denver, CO, USA) and two force platforms (AMTI, Watertown, MA, USA). Test order was randomized.

Subjects performed 3 successful trials for each movement on each of the three surfaces [SM, SP, CO] which represented the independent variables. **Main Outcome Measures:** Derived mean and peak lower extremity kinematic data (dependent variables of ankle, knee, and hip ROM) were statistically evaluated with paired t tests (p set *a priori* to 0.05) for differences between conditions for right-side peak and mean ROM. **Results:** For cutting activities, mean coronal plane hip ROM for SM (-11.01 ± 9.42°) differed from CO (-9.81 ± 8.97°) (p = 0.037). Peak hip adduction ROM demonstrated a marked trend between SM (0.83 ± 9.28°) and CO (2.12 ± 8.69°), though not statistically significant (p = 0.09). Mean knee frontal plane ROM demonstrated a similar trend between SM (5.60 ± 7.45°) and CO (4.42 ± 6.95°) (p = 0.068). For drop vertical jump, mean hip coronal plane ROM demonstrated a significant difference (p = 0.03) between CO (-10.37 ± 4.63°) and SP (-11.03 ± 5.15°) **Conclusions:** Though some statistically significant differences were noted between surface conditions, the majority of kinematic measures saw no statistically nor clinically significant differences in peak or mean lower extremity ROM between athletic flooring surfaces across tasks. In fact, those kinematics determined statistically significant between flooring surfaces were not consistent with those of clinical concern for lower extremity musculoskeletal injury risk (i.e., peak frontal plane knee valgus and peak sagittal plane knee flexion).

Strength Training Progression Effectiveness Using a Load Cell

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Context: Elastic resistance (ER) is a common training mode used by healthcare professionals to aid patients in gaining strength. Currently progression with ER is based on the perceived exertion of the exercise or completion of targeted number of repetitions, specific resistance is typically unknown. **Objective:** To determine if knowledge of load during ER exercise prescription will increase strength gains during exercises. **Design:** Repeated Measure. **Setting:** Clinical laboratory. **Patients or Other Participants:** Seventy-three healthy subjects (32 ± 14 yrs, 73 ± 16 kg, 168 ± 12 cm) volunteered. **Interventions:** Participants were randomized into two strength training groups, ER using a load cell (LC) that displays force during exercise or ER only. Those participants randomized into the LC group used a new device called the Smart Handle (Patterson Medical Supply, Chicago, IL) to complete all of exercises. Each participant completed the same three shoulder and hip exercises three times each week for 8 weeks, performing three sets of 10 repetitions for each exercise. The LC group was provided with a set load for exercises each session whereas the ER group was increased based on their self-perceived intensity using the Thera-band Resistance Intensity Exercise Scale. Participant's isometric strength was tested at baseline and upon program completion using isokinetic dynamometer (BTE Primus, Hanover, MD), two trials of isometric strength tests for shoulder abduction (SAb), shoulder external rotation (SER), hip abduction (HAb), and hip extension (HEx). All measures of torque were normalized to bodyweight. **Main Outcome Measures:** Change in torque normalized to bodyweight was compared between two groups using independent t-tests, to identify differences between groups. **Results:** A total of 82 participants were enrolled with 14% dropout in the ER group and a 7% dropout rate in the LC group. SAb strength gains did not differ between LC group (4.3 ± 3.4% BW) compared to ER group (3.4 ± 3.8% BW, p = 0.29, d = 0.25). SER strength gains did not differ between LC group (2.2 ± 2.1% BW) compared to ER group (2.4 ± 2.1% BW, p = 0.77, d = 0.10). HAb strength gains did not differ between LC group (11.5 ± 6.4% BW) compared to ER group (8.2 ± 6.9% BW, p = 0.06, d = 0.50). HEx strength gains did not differ between LC group (12.2 ± 9.6% BW) compared to ER group (10.1 ± 7.5% BW, p = 0.34, d=0.24). **Conclusions:** Both groups increased strength due to individual supervision, constantly evaluating degree of difficulty associated with exercise and providing feedback while using ER. Using a LC is as effective as supervised training and could provide value in a clinic setting when patients are working unsupervised.

The Use of the Lever Sign for the Diagnosis of Anterior Cruciate Ligament Ruptures: Preliminary Results for Diagnostic Accuracy

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Context: The Lever Sign is an orthopedic special test that was recently developed for the diagnosis of anterior cruciate ligament (ACL) ruptures. Although recent investigations suggest that the Lever Sign possesses excellent diagnostic accuracy, patients were assessed immediately prior to surgical intervention, and/or under anaesthesia. Thus, little is known of the diagnostic accuracy of the Lever Sign when used during more common (ie, non-surgical) clinical evaluation conditions. **Objective:** To investigate the diagnostic accuracy of the Lever Sign during initial evaluation within a sports medicine clinic, and to compare its clinical utility to the Lachman and anterior drawer tests. **Design:** Prospective. **Setting:** Sports medicine clinic. **Patients or Other Participants:** Thirty-one patients (male = 21, female = 10, age = 29.2 ± 13.2 [range = 12-62]) with complaints (eg, symptoms, mechanism of injury) that warranted clinical evaluation of the ACL and a magnetic resonance imaging (MRI) for diagnosis. **Interventions:** Healthcare professionals (physicians, physician assistants, athletic trainers) within the sports medicine clinic were trained on the use of the Lever Sign prior to data collection. Results (positive, negative) from the Lever Sign, Lachman, and anterior drawer were recorded at intake for all patients. MRI results (positive, negative) were recorded per the radiologist's report. **Main Outcome Measures:** Data were analyzed using contingency tables to calculate diagnostic values for the Lever Sign, Lachman, and anterior drawer. Sensitivity, specificity, positive likelihood ratio, and negative likelihood ratio values were reported with 95% confidence intervals (95% CI). PABAK (Prevalence and Bias Adjusted) Kappas were calculated to express agreement between each test and the MRI finding. **Results:** MRI results indicated that 35.5% (n = 11) of the patients suffered a complete tear of the ACL. The Lever Sign demonstrated lower sensitivity (0.80; 95% CI = 0.44-0.97) than the Lachman (0.90; 95% CI = 0.55-1.00) and anterior drawer (0.88; 95% CI = 0.47-1.00). Specificity values were comparable between the Lever Sign (0.79, 95% CI = 0.54-0.94), Lachman (0.79; 95% CI = 0.54-0.94) and anterior drawer (0.84; 95% CI = .60-0.97). The Lever Sign also demonstrated lower positive (3.80; 95% CI = 1.51-9.58) and negative (0.25; 95% CI = 0.07-0.89) likelihood ratios when compared to the Lachman (positive likelihood ratio = 4.28, 95% CI = 1.75-10.46; negative likelihood ratio = 0.13; 95% CI = 0.02-0.83) and anterior drawer (positive likelihood ratio = 5.54, 95% CI = 1.90-16.17; negative likelihood ratio = 0.15, 95% CI = 0.02-0.94). PABAK for the anterior drawer (0.70) and Lachman (0.66) tests exceeded that for the Lever Sign (0.52). **Conclusions:** These preliminary findings suggest that, on its own, the Lever Sign possesses good diagnostic accuracy when used under routine clinical evaluation settings. However, when compared to the Lachman and anterior drawer tests, the Lever Sign underperformed and may not add any meaningful information to the clinical evaluation process. These preliminary results contrast currently available evidence. However, it is important to interpret these results cautiously because more research is needed to better understand the diagnostic accuracy of the Lever Sign.

The Effectiveness of the Elmslie-Trillat Procedure Versus Lateral Release in Patients With Patellar Instability: A Systematic Review

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Context: Patellofemoral instability (PFI) is commonly associated with anterior knee pain, and occurs as a result of overuse, congenital malalignment, structural insufficiency, impaired motor control, and trauma. There is a high reoccurrence of patellar dislocations with conservative treatment, and clinicians often recommend surgical intervention to enhance patient outcomes; however, the efficacy of the Elmslie-Trillat procedure (ETP) compared to lateral release (LR) to correct patellofemoral instability (PFI) is unclear. **Objective:** To systematically review the literature and evaluate the effectiveness of the Elmslie-Trillat procedure compared to the lateral release procedure in improving patellar stability. **Data Sources:** Research articles were identified from the following electronic databases: Cumulative Index Nursing and Allied Health Literature, Medline, PubMed, and SPORTDiscus, from July 2007-October 2016. Search terms included: "Elmslie-Trillat Procedure"; "Lateral Release"; "Elmslie-Trillat Procedure OR Lateral Release AND patella instability"; "Elmslie-Trillat Procedure AND Lateral Release AND patellar instability," resulting in 608 studies. **Study Selection:** Studies were included if they met the following criteria: (1) peer-reviewed, (2) controlled/comparative clinical trial or randomized clinical trial (3) written in English, (4) full-text reports, (5) focused on specific surgical procedure, (6) measured patient outcomes. **Data Extraction:** Two reviewers independently assessed each study on the Physiotherapy Evidence Database (PEDro) scale. Data of interest were methodological assessment and descriptive data of participant demographics (e.g. patellar instability, age, gender, and surgical intervention), and

outcome measures (e.g. means, standard deviations, and 95% confidence interval (CI). **Data Synthesis:** Six studies met the inclusion criteria. The PEDro scores for the 6 studies ranged from 5-6 points (mean = 5.8 ± .40). Data was collected on subjects with PFI who underwent surgical intervention (n = 307). The mean participant age was 23.2 ± 7.2 years (range 11-52). Fourteen percent of patients were male (n = 44); 28% were women (n = 86); and gender was unknown for 56% of patients (n = 177). Three studies examined the efficacy of LR determined by pre-post outcome scales. Within the three studies, mean Kujala scores improved significantly ($p = .002$) from 66.38 ± 16.64 to 94.31 ± 10.46, mean Tegner scores improved significantly ($p < .001$) from 4.08 ± 2.14 to 8.13 ± 1.75, and mean Lateral Shift Stress Ratio scores improved significantly ($p < .05$) from 41 ± 3.5 to 54.9 ± 4.3. Three studies examined the efficacy of ETP determined by pre-post outcome scales. Within the three studies, mean Knee Society Score for pain improved significantly ($p < .001$) from 74.5.38 ± 13.6 to 87.7 ± 9.2, mean Knee Society Score for function improved significantly ($p < .001$) from 82 ± 19.6 to 88.8 ± 12.3, mean Lysholm scores improved significantly ($p < .001$) from 42.2 (CI = 29.33-55) to 60.5 (CI = 43.4-77.6), and mean International Knee Documentation Committee scores significantly improved ($p < .001$) from 40.8 (CI = 29.4-52.2) to 67 (CI = 52.7-81.1). **Conclusions:** Elmslie-Trillat and Lateral Release procedures both demonstrated significantly improved pre-post outcome scores. Patients with PFI would benefit from surgical intervention; however, surgical intervention should be decided by patient circumstances (e.g. distal realignment necessity) and clinician expertise.

Master's Poster Award Finalist

Clinical Presentations at the Point-of-Care of Common Sport-Related Knee Injuries: A Report From the Athletic Training Practice-Based Research Network

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Context: Sport-related knee injuries are common, often presenting similar clinically. Identifying differences in clinical presentation of knee injuries may enhance evaluation. **Objective:** To identify clinical presentation differences in patients diagnosed by Athletic Trainers (AT) with a meniscus tear (MT), medial collateral sprain (MCL) or knee pain (KP). **Design:** Retrospective analysis of electronic medical records. **Setting:** 66 athletic training facilities (high school = 55, collegiate = 9, clinic = 2) across 16 states within the Athletic Training Practice-Based Research Network. **Patients or Other Participants:** 170 ATs (female = 107, age = 28.6 ± 7.8 years, years certified = 3.9 ± 5.3, years employed at site = 1.4 ± 3.4) practicing in athletic training facilities during the study period. **Interventions:** Initial evaluation forms from patient records were reviewed and identified using ICD-9 diagnostic codes (MT: 836.2, MCL: 844.1, KP: 719.46). ATs created patient records between October 2009-October 2016. **Main Outcome Measures:** Summary statistics (percentages, frequencies) were calculated to describe evaluation findings, including sex, sport, mechanisms of injury (MOI), AROM, manual muscle test (MMT), special tests, and participation status. **Results:** 460 patients were diagnosed with MT (23.0%, n = 106/460; age = 17.2 ± 2.0 years), MCL (34.4%, n = 158/460; age = 16.9 ± 2.1 years), and KP (42.6%, n = 196/460; age = 16.4 ± 2.1 years) injuries. Patients sought treatment within 6.6 ± 13.4, 3.1 ± 8.9, and 6.5 ± 14.1 days post-injury for MT, MCL, and KP, respectively. Males sustained the majority of MT (74.5% male, n = 79/106) and MCL (74.1% male, n = 117/158) injuries; females sustained more KP injuries (59.7%, n = 117/196). Football was the most commonly reported sport for all diagnoses (MT = 30.2%, n = 32/106; MCL = 58.9%, n = 93/158; KP = 18.4%, n = 36/196). Common MOI were non-contact (37.7%, n = 40/106) or twisting (24.5%, n = 26/106) for MT; contact (60.1%, n = 95/158) or non-contact (17.1%, n = 27/158) for MCL; and non-contact (50.0%, n = 98/196) or contact (19.9%, n = 39/196) for KP. At evaluation, reported pain (0-10) was similar for MT (5.5 ± 2.1) and MCL (5.5 ± 2.0), but lower for KP (4.6 ± 2.3). Most patients were full-weight bearing (MT = 68.9%, n = 73/106; MCL = 62.0%, n = 98/158; KP = 88.3%, n = 173/196) and presented with mild or no limitations in AROM (MT = 75.5%, n = 80/106; MCL = 71.6%, n = 114/158; KP = 88.3%, n = 173/196). Strength deficits (MMT ≤ 4/5) were more common for MT (quadriceps = 51.5%, n = 35/68; hamstrings = 50.0%, n = 39/78) than MCL (quadriceps = 41.2%, n = 40/97; hamstrings = 34.2%, n = 26/76) and KP (quadriceps = 36.8%, n = 46/125; hamstrings = 27.2%, n = 34/125). Frequent positive special tests (≥50% positive for patients) included: McMurray's (positive = 72.8%, n = 59/81) and Apley compression (positive = 65.9%, n = 29/44) for MT, and valgus stress test (positive = 81.1%, n = 120/148) for MCL. No special tests were positive in ≥50% of KP patients. At diagnosis, most patients with MT (70.8%, n = 75) and MCL (70.9%, n = 112) injuries were restricted from sport participation, while most patients with KP (51.0%, n = 100) were restriction-free. **Conclusions:** MT and MCL injuries present similarly across major clinical findings including pain, AROM deficits, and participation status, but KP injuries present differently. More strength deficits were noted with MT. No special tests helped to rule-in KP. Educating ATs on key clinical findings may enhance clinical care, aiding in more efficient injury diagnoses.

Doctoral Poster Award Finalist

A Randomized Controlled Trial Investigating the Effects of Ankle Rehabilitation Programs on Self-Reported Outcomes in Patients With Chronic Ankle Instability

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Context: Various rehabilitation exercises have been used to increase overall self-reported function for individuals with Chronic Ankle Instability (CAI). Research has shown that rehabilitation programs incorporating resistance band and wobble board exercises are effective at improving patient self-reported outcomes; however, it is unknown if there is any increased improvement by combining them. **Objective:** To determine the effectiveness of three different 4-week rehabilitation programs on patient self-reported outcomes for patients with CAI as assessed by the Cumberland Ankle Instability Tool (CAIT). **Design:** Randomized Controlled Trial **Setting:** Research Laboratory **Patients or Other Participants:** Forty patients with CAI were block randomized into four rehabilitation groups: wobble board (WB) (n = 10, 166.25 ± 7.90 cm, 68.67 ± 20.65 kg, 23.10 ± 3.98 yrs), resistance band (RB) (n = 10,157.27 ± 26.18 cm, 81.68 ± 22.62 kg, 22.50 ± 1.08 yrs), combination (WB/RB) group (n = 10,168.28 ± 9.21 cm, 73.54 ± 19.01 kg, 23.00 ± 4.03 yrs), and control (CON) (n = 10, 168.79 ± 5.71 cm, 77.60 ± 21.02 kg, 24.10 ± 4.15 yrs) **Interventions:** Each rehabilitation program was progressive and consisted of 3 sessions a week for 4 weeks. The WB group performed 5 trials of clockwise/counterclockwise rotations changing direction every 10 seconds during each 40 second trial. The patient would start on level 1 and could progress to level 5. The RB group performed 3 sets of 10 repetitions of ankle plantarflexion, dorsiflexion, inversion and eversion using a resistance band. Each week the patient would progress to a more difficult band color (red, green, blue and black). The WB/RB group completed both wobble board and resistance band programs during each session. The CON group did not complete any exercises and was instructed to maintain normal physical activity. Patient self-reported outcomes were assessed using the CAIT prior to and following the rehabilitation intervention. **Main Outcome Measures:** A 4 x 2 (group, time) mixed model ANOVA was used for data analysis. Tukey's HSD post-hoc tests were conducted on significant interactions. An a priori alpha level was set at 0.05 for all analyses **Results:** A significant group by time interaction was observed ($F_{1,36}$ = 5.69, P = 0.003). Post-hoc analyses indicated the four groups were not significantly different prior to rehabilitation (WB_{pre} = 18.90 ± 2.33, RB_{pre} = 14.70 ± 3.62, WB/RB_{pre} = 14.90 ± 4.95, CON_{pre} = 15.10 ± 3.96; p > 0.05). The WB, RB, and WB/RB groups were significantly better than the CON group after rehabilitation (WB_{post} 20.10 ± 3.28, RB_{post} = 21.90 ± 4.36, WB/RB_{post} =21.00 ± 4.50, CON_{post} = 15.30 ± 3.53; p > 0.05). The RB and WB/RB groups demonstrated a significant change from pre-rehabilitation to post-rehabilitation. The WB group CAIT scores did not change significantly from pre- to post-rehabilitation. **Conclusions:** All three rehabilitation groups demonstrated improved patient self-reported outcomes as compared to the CON group. Only the RB and WB/RB groups demonstrated a statistically significant improvement in patient self-reported outcomes following rehabilitation. Rehabilitation including RB may be more beneficial at improving patient self-reported outcomes as assessed by the CAIT.

Doctoral Poster Award Finalist

Landing Biomechanics Influence Physiological Markers of Muscle Tissue Loading in Response to High-Intensity Exercise

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Context: High training load (HTL) exposure and stiff landing biomechanics increase an individual's risk of lower extremity injury during sport and physical activity participation. Landing biomechanics that leverage the stretch-shortening cycle to control joint motion during landing may result in greater eccentric loading that can be detected with biomarkers of skeletal muscle tissue stress such as circulating serum creatine kinase concentration [CK-MM]. Understanding the influence of landing biomechanics on the protective effects of force dissipation through dynamic muscle tissue loading during sport activity may lend insight to mechanisms responsible for mitigation of injury risk during HTL exposure. **Objective:** To investigate the influence of a low-risk / soft or high-risk / stiff movement profile on muscle tissue loading represented by serum [CK-MM] in response to HTL exposure. **Design:** Cross-sectional. **Setting:** Research laboratory. **Patients or Other Participants:** 40 physically active, healthy, college-aged field or court sport female athletes volunteered for participation in this study. Participants were assigned to a low-risk / soft (n = 21; age = 20.6 ± 1.9 yrs, height = 142.9 ± 44.6 cm, mass = 64.8 ± 7.9 kg) or a high-risk / stiff (n = 19; age = 20.5 ± 1.4 yrs, height = 163.4 ± 24.4 cm, mass = 61.0 ± 6.3 kg) movement profile group defined by The Landing Error Scoring System. **Interventions:** Participants completed five cycles of 5-minute treadmill running at a speed coincident with 110-120% ventilatory threshold and 10 jump-landings from a 30 cm box. **Main Outcome Measures:**

Blood samples were collected at baseline and 30 minutes following controlled HTL exposure. Menstrual cycle phase, prior diet and exercise were controlled. Samples were analyzed using commercially available ELISA kits to determine [CK-MM] representative of skeletal muscle tissue loading. Percentage change scores (%Δ) of [CK-MM] from baseline to post-HTL exposure were calculated and compared between low-risk / soft and high-risk / stiff movement profile groups using an independent samples t-test. **Results:** There was a significant, strong effect of movement profile on changes in circulating [CK-MM] ($t_{21.63}$ = 2.43, P = 0.024, d = 0.91; Low-Risk / Soft = 68.62 ± 115.61 %Δ, High-Risk/Stiff = 6.12 ± 22.21 %Δ). After exposure to HTL, individuals with a low-risk/soft movement profile exhibit greater increases in levels of circulating [CK-MM], suggestive of greater skeletal muscle tissue loading. **Conclusions:** Female athletes with a low-risk / soft movement profile characterized by greater sagittal plane force dissipation using the stretch-shortening cycle appear to leverage greater skeletal muscle tissue loading during HTL exposure compared to their high-risk / stiff landing counterparts. Greater muscle tissue loading in the low-risk / soft movement profile group may explain physiological mechanisms such as lower extremity joint and ligamentous tissue loading underlying a decreased risk of injury during sport and physical activity participation.

Doctoral Poster Award Finalist

Sensory Disconnect and Force Control Deficits Following Hamstring Strain Injuries

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Context: Hamstring strain injury (HSI) remains one of the highest occurring injuries in sport and symptoms of tightness are commonly known to persist following return-to-play. The patients' perception of tightness has never been explored even though neural tension has been linked to HSI. It remains unclear if these symptoms have implications on the mechanical and proprioceptive function of the hamstrings that could result in dysregulation of neuromuscular control during high-speed activity. **Objective:** To quantitatively measure hamstring tightness and determine its relationship with extensibility and force control. Following HSI, it is hypothesized that discordant sensory processing influences neuromechanical function of the hamstrings. **Design:** Cross-sectional study. **Setting:** Research laboratory. **Patients or Other Participants:** Twenty-eight participants(INJ;20.4 ± 1.2 yrs, 70.7 ± 14.1kg, 172.5 ± 9.9 cm) with a history of HSI and 27 controls (CON; 20.7 ± 1.6 yrs, 70.9 ± 11.7 kg, 172.6 ± 9.1 cm) matched for limb dominance volunteered for this study. **Interventions:** Perceived tightness was quantified using a Visual Analog Scale and extensibility was assessed with the Active Knee Extension (AKE). To examine force control, participants matched a prescribed line of a ramp-and-hold (20% and 40% MVICs) displayed on a monitor by using the hamstrings to pull against the lever of a modified isokinetic dynamometer. **Main Outcome Measures:** Subjective tightness was measured to the nearest millimeter and converted to a percentage, while the average of 3 trials was analyzed for the AKE(°). Root-mean-square error(RMSE,NM/lb) was calculated for the ramp-and-hold task. Paired samples and independent t-tests were employed to examine inter-limb and group differences. Pearson correlation coefficients were calculated to examine relationships between dependent variables. **Results:** Perceived tightness was significantly higher in the HSI limb (25 ± 20.1%) compared to the uninjured limb (18.3 ± 20.2%, P = .031) and the matched CON limb (14.6 ± 14.1%, P = .036), while no difference existed between groups for the contralateral limb (P = .75). Extensibility in INJ was significantly decreased in the previously injured (60.3 ± 14.6°, P = .03) and uninjured (59.1 ± 13.7, P = .023) limbs compared to CON (68.5 ± 11.3, 67.7 ± 11°), yet no significant inter-limb differences existed in INJ (P = .30). RMSE was significantly greater in INJ at both 20% (0.128 ± .10 Nm/lb, P = .027) and 40% MVIC (.067 ± .03 Nm/lb, P = .025) compared to CON (.085 ± .03, .05 ± .02 Nm/lb). Perceived tightness was significantly correlated with force control at both 20% (P = .003, r = .40) and 40% (P < .001, r = .46) MVICs. **Conclusions:** Perceived tightness significantly differed between limbs in the INJ group, yet no inter-limb difference existed for extensibility, representing a sensory disconnect. This aberrant sensory input may be due to neuromechanical decoupling between the nervous system and musculotendinous properties that could have also resulted in the greater force control errors observed. Altered perception of tightness and the inability to accurately reproduce specific force levels could overload the hamstrings during rapid eccentric lengthening. This highlights that traditional stretching and management protocols may not be sufficient if perceived tightness is not relieved. Future research should explore the alleviation of tightness and the relationship between sensory and force control deficits and hamstring re-injury.

Undergraduate Poster Award Finalist

Landing Energetics and Trunk Position for Patellofemoral Pain Patients Can Differ Based on Quadriceps Central Activation Ratio

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Context: Quadriceps weakness is one of contributing factors to patellofemoral pain (PFP). Although there are objective methods to quantify quadriceps neuromuscular activation (e.g., central activation ratio: CAR), researchers have often classified PFP research patients using only self-reported questionnaires such as a Visual Analog Scale (VAS) and/or Kujala Anterior Knee Pain (KAKP). Since these self-reported data do not provide neuromuscular activation characteristics, it could be important to consider objectively-measured quadriceps CAR values when studying movement mechanics with PFP patients. **Objective:** Compare landing energetics and trunk position between two subgroups of PFP patients who scored differently on quadriceps CAR but similarly on two common PFP classification questionnaires (VAS and KAKP). **Design:** Single cohort. **Setting:** Laboratory. **Patients or Other Participants:** 30 (M = 16, F = 14) PFP patients participated: 15 Quadriceps Deficit (QD: CAR < 0.95; CAR = 0.91 ± 0.03; VAS = 3.87 ± 1.3; KAKP = 82.9 ± 6.6) and 15 Quadriceps Functional (QF: CAR ≥ 0.95; CAR = 0.97 ± 0.01; VAS = 3.93 ± 0.7; KAKP = 79.3 ± 7.9). **Interventions:** Subjects performed three quadriceps maximal voluntary contractions with an isokinetic dynamometer while superimposed burst was transmitted to two electrodes placed on their quadriceps to calculate CAR for a group assignment (QD or QF). Subjects performed 5 jumps consisting of a maximal vertical forward jump plus side-cutting at 90 deg while movement mechanics were collected using high-speed video and a force plate. Joint power was calculated using net joint moment and angular velocity. Functional analyses (α=0.05) were used to detect mean differences. If 95% confidence intervals did not overlap zero, significant between-group differences existed. **Main Outcome Measures:** Lower extremity joint power (W/kg) and trunk angles (deg) from initial contact (0%) to toe-off (100%) during side-cutting. 0-50% indicates the power absorption phase and 51-100% indicates the power generation phase. **Results:** Relative to the QF group, the QD group displayed up to (i) 2 W/kg more ankle power absorption at 0-7% and 39-50% of stance, (ii) 1.6 W/kg less knee power generation at 78-90% of stance, (iii) 2.3 W/kg less hip power absorption at 0-8% of stance and 1 W/kg less hip power generation at 55-61% of stance, (iv) 9.5 deg less sagittal trunk flexion at 6-100% of stance, and (v) 2.5 deg less lateral trunk flexion at 10-24% of stance. **Conclusions:** It is important to consider how objective neuromuscular activation characteristics can affect movement and subsequent intervention in this patient population. Reduced knee power generation during push-off might be due to quadriceps activation deficits. A more upright trunk position may be an attempt to reduce support from the knee and hip extensors. While no differences in knee power absorption and less hip power absorption in the QD group were observed, landing impact loads seem to be attenuated by the ankle.

Insidious Talus Fracture in a Collegiate Football Player

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Background: A 20 year-old male collegiate football player reported that while running downfield in a football game that he apparently twisted his ankle while decelerating. He complained of immediate and progressive worsening pain with activity. On initial exam he was unable to fully weight bear and ambulate without difficulty. There was pain to palpation over the sinus tarsi and along the anterior talar fibular ligament. But curiously there was no laxity with anterior drawer and talar tilt. He had a negative Kleiger's test and no pain over the posterior ankle joint. There were no neurovascular symptoms present. **Differential Diagnosis:** Lateral ankle sprain, peroneal muscular strain, stress fracture, Os Trigonum fracture, osteochondral lesion, tarsal coalition and talus fracture **Treatment:** On-site radiographs revealed a large Os Trigonum but no acute separation. No acute fracture noted on any of the radiographic views taken. The athlete was treated with RICE, placed in a walking boot and given crutches for ambulation. He was treated the next three days in the athletic training clinic with whirlpool, ultrasound, ROM activities and ankle muscular strengthening exercises but no improvement was noted. Athlete was referred to an orthopedic foot and ankle specialist and repeat x-rays showed no boney fracture. The subtalar joint was injected with a corticosteroid and the athlete was instructed to continue with therapy. After seven days of continued therapy, the athlete could fully weight bear and walk but was unable to run full speed or perform sports related cutting maneuvers pain-free. He was referred back to the orthopedic specialist and an MRI was ordered to rule out possible tarsal coalition. The MRI revealed non-displaced fracture to the anterior-superior dome of the talus. The athlete was placed in a NWB short-leg cast for four weeks and permitted upper

body lifting only. At four weeks the cast was removed and the athlete began therapy for lower extremity muscular strengthening and proprioception. He returned to full activity seven days later without further incident. **Uniqueness:** According to the literature, fractures to the talus represent only 1-2% of all fractures. Of these rare fractures only about 3-10% involve the head of the talus. Talus fractures often present as severe ankle sprains and the injury is often missed because of inconspicuous radiographic findings. Missed fractures of the talus can lead to long-term morbidity and result in mal-union, non-union, and post-traumatic arthritis of the subtalar joint. Most authors recommend conservative treatment of fractures to the talus prior to surgical intervention. **Conclusions:** This case illustrates the appropriate evaluation and conservative treatment leading to complete resolution of an unusual ankle injury diagnosed as a fracture to the talus. Most lesions of the talus can be diagnosed acutely but often are identified sometime after an injury, particularly following trauma to the lateral ligamentous complex. Because fractures of the talus are uncommon and the clinical and radiographic findings are often subtle, these injuries are often overlooked or misdiagnosed as ankle sprains. This case supports the non-operative management and care for a non-displaced fracture of the talus. The athlete is currently asymptomatic and has returned to all athletic and daily living activities.

The Influence of Prior Concussion History on Teachers' Knowledge and Confidence in the Secondary School Setting

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Context: As part of the interdisciplinary concussion management team, secondary school teachers play a significant role in supporting a student's return to the classroom after sustaining a concussion. However, little is known regarding teachers' perceived knowledge and confidence in their knowledge regarding sport-related concussion. **Objective:** To investigate the influence of teacher's personal prior concussion history on their knowledge and confidence regarding concussion. **Design:** Cross sectional **Setting:** Self-report online survey. **Patients or Other Participants:** There were 426 secondary school teachers across 45 states who accessed the survey (7.4% response rate), and 349 completed surveys were analyzed. Of the 349 teachers (125 males, 194 females, 30 missing; years experience = 15.51 ± 10.82; age = 44.9 ± 12), 109 had previously sustained a concussion (TeachwHx) and 209 had not (TeachwoHx) (31 missing). **Interventions:** Teachers were invited via email to complete the *Beliefs, Attitudes, and Knowledge of Pediatric Athletes with Concussions* (BAKPAC) survey. A separate version of the BAKPAC, a previously validated instrument, was developed for teachers (BAKPAC-TEACH). The BAKPAC-TEACH was piloted and minor clarifications to wording were made prior to dissemination. The instrument contained several closed-ended and 4-point Likert-type items regarding perceived knowledge and confidence in their knowledge of concussion. **Main Outcome Measures:** Descriptive statistics were calculated to examine teachers' overall knowledge, confidence, and importance of concussion. Dependent variables were participants' responses to Likert-scale items (ie., higher scores indicated greater perceived knowledge and confidence). Separate knowledge and confidence composite scores were computed by totaling values of 7 Likert-type items and calculating the average back to the original 4-point scale. Mann Whitney U tests ($P < .05$) were used to describe differences in knowledge and confidence between groups. **Results:** Overall, TeachwHx were moderately knowledgeable (Mdn = 3.0, M = 2.9/4.0 ± 0.64, P < .001) and moderately confident in their knowledge (Mdn = 3.0, M = 2.8/4.0 ± 0.68, P < .001) of concussion; whereas, TeachwoHx were minimally knowledgeable (Mdn = 2.4, M = 2.5/4.0 ± 0.66) and minimally confident in their knowledge (Mdn = 2.3, M = 2.36/4 ± 0.72). Additionally, TeachwHx were more knowledgeable and confident regarding return-to-learn criteria (Mdn = 3.0, M = 2.48/4 ± 0.90, P = .002) and return-to-activity criteria (Mdn = 3.0, M = 2.80/4 ± 0.91, P < .001) than TeachwoHx for return-to-learn (Mdn = 2.0, M = 2.15/4 ± 0.84) and return-to-activity (Mdn = 2.0, M = 2.29/4 ± 0.91). Both teacher groups believed it was extremely important for teachers to recognize the steps to follow if a student has a concussion (Mdn = 4.0, M = 3.73/4 ± 0.50, P = ,928) and extremely important to limit students' cognitive activities immediately following a concussion (Mdn = 4.0, M = 3.42/4 ± 0.71, P = .414). **Conclusions:** Teachers with a personal history of concussion were more knowledgeable and confident in their knowledge of adolescent concussion, return-to-learn, and return-to-activity than teachers without a personal history of concussion. Although teachers believed it is important to support students after a concussion, targeted concussion education is recommended for teachers without personal history of concussion.

The Influence of Institutional Stakeholders on Division I Student-Athlete Concussion Reporting Behaviors

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Context: Institutional stakeholders, such as coaches, sports medicine professionals, and athletic administrators, may exert influence on student-athletes' decisions to report concussion. Effective measures for improving concussion reporting should target student-athletes, but may also need to account for the beliefs of other stakeholders. **Objective:** To determine the whether institutional stakeholders' concussion knowledge, attitudes (beliefs regarding what will happen if one performs a behavior), subjective norms (beliefs regarding what others expect one to do) predict student-athlete concussion reporting intentions and behaviors. **Design:** Cross-sectional. **Setting:** Clinical Research Laboratory. **Patients or Other Participants:** Ninety-seven collegiate student-athletes (response rate, RR = 15%), 18 coaches (RR = 52%), 13 sports medicine professionals (RR = 40%), and 8 athletic administrators (RR = 40%) from a Division I convenience sample. **Interventions:** Student-athletes completed a previously published survey to assess their concussion reporting intentions (8 items) and behaviors (10 items). Stakeholders completed a survey to assess the following concussion reporting factors: knowledge (13 items), attitudes (8 items), and subjective norms (4 scenarios, 18 items). All survey items used a 7-point Likert-scale (1 = strongly disagree to 7 = strongly agree). **Main Outcome Measures:** All survey responses were reverse-coded where appropriate and averaged to create a composite score for each reporting factor. Student-athlete and stakeholder responses were linked

based on team assignment, where appropriate. If more than one coach, sports medicine professional, or athletic administrator was associated with a sport, the scores were averaged across stakeholders of the same type. Scores ranged from 1-7, with higher scores indicating better concussion reporting intentions, behaviors, knowledge, attitudes, and subjective norms. Separate multivariate regression models (one per stakeholder group) were developed, using the enter method, with stakeholder knowledge, attitudes, and subjective norms predicting student-athlete concussion reporting intentions and behaviors ($a = 0.05$). **Results:** No models were significant, but we observed a trend ($F_{3,68} = 2.62$, $p = 0.058$) such that coach knowledge and subjective norms, but not attitudes, significantly predicted student-athlete concussion reporting behaviors. For every 1-point increase in coach concussion knowledge, student-athlete concussion reporting behaviors improved by 0.08 ($\beta = 0.083$, $p = 0.020$). However, for every 1-point increase in coach subjective norms, student-athlete concussion reporting behavior declined by 0.08 ($\beta = -0.078$, $p = 0.032$). **Conclusions:** Institutional stakeholders may not exert strong influence over student-athlete concussion reporting intentions and behaviors. Concussion education efforts should predominantly focus on student-athletes, but may also need to account for the role of the coach as we found that a coach's concussion knowledge may positively influence student-athlete concussion reporting. However, student-athletes may be slightly less likely to report a concussion if their coach has higher expectations regarding concussion reporting. Further research is needed to determine how other stakeholders, such as parents or fans, influence concussion reporting and whether stakeholders may play a bigger role in other settings, such as youth sports, other levels of collegiate competition (e.g. NAIA, Division II/III, etc), and professional sports.

Influence of Prior Concussion Education on Club Swim Coaches' Perceived Importance, Knowledge, and Confidence Regarding Sport-Related Concussion

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Context: While all concussion legislation covers high school athletics, fewer state laws extend to club sports. Swimming is one sport that has a high number of club participants and while concussions occur less frequently than other sports, education regarding concussions is nonetheless important. **Objective:** To determine perceived importance, knowledge, and confidence in knowledge regarding adolescent concussion among coaches with and without prior concussion education **Design:** Cross-sectional. **Setting:** Self-reported online survey. **Patients or Other Participants:** 385 club swim coaches (207 males, 178 females; age = 43.0 ± 12.7 years; coaching experience = 14.5 ± 11.2 years) from a convenience sample of 17,990 (response rate = 2.1%) coaches from 46 states. **Interventions:** Participants were solicited via email to complete the *Beliefs, Attitudes, and Knowledge of Pediatric Athletes with Concussions* (BAKPAC) survey. The BAKPAC included 20, 4-point Likert-scale items to assess participants' perceived importance (6), knowledge (7), and confidence in their knowledge (7) for several topics related to concussion. **Main Outcome Measures:** The independent variable was prior concussion education and dependent variables were participants' responses to the 20 Likert-scale items. A higher score indicated a higher perceived knowledge level, higher confidence in their knowledge, and perceived the concepts to be more important. Composite knowledge and confidence scores were achieved by totaling all values and then calculating the average back to the Likert scale (total divided by 4). Descriptive statistics were utilized to describe importance, knowledge, and confidence in knowledge and Mann Whitney U tests were used to assess group differences ($p < .05$). **Results:** 242 coaches had prior concussion education while 143 did not. Coaches with prior education had significantly higher composite scores for importance (3.87 ± .19 vs 3.83 ± .19, $p = .032$), perceived knowledge (3.02 ± .57 vs 2.53 ± .56, $p < .001$), and perceived confidence in their knowledge (3.04 ± .58 vs 2.48 ± .55). Differences in importance were noted specifically for removal from activity (3.93 ± .38 vs 3.85 ± .52, $p = .044$) and limiting cognitive activity (3.50 ± .69 vs 3.29 ± .87, $p = .038$). Perceived knowledge was greater among coaches with prior education for prevention (3.33 ± .55 vs 2.98 ± .55, $p < .001$), physical signs/symptoms (3.40 ± .53 vs 2.98 ± .58, $p < .001$), cognitive signs/symptoms (3.24 ± .64 vs 2.73 ± .69, $p < .001$), treatment/management (3.10 ± .70 vs 2.57 ± .72, $p < .001$), academic accommodations (2.56 ± .95 vs 2.03 ± .84, $p < .001$), return-to-learn (2.46 ± .94 vs 1.94 ± .86, $p < .001$), and return-to-play (3.07 ± .82 vs 2.44 ± .85, $p < .001$). Perceived confidence in knowledge was significantly greater in coaches with prior education for prevention (3.43 ± .57 vs 3.09 ± x.64, $p < .001$), physical signs/symptoms (3.40 ± .58 vs 2.97 ± .61, $p < .001$), cognitive signs/symptoms (3.18 ± .73 vs 2.61 ± .74, $p < .001$), treatment/management (3.08 ± .71 vs 2.47 ± .73, $p < .001$), academic accommodations (2.51 ± .95 vs 1.99 ± .81, $p < .001$), return-to-learn (2.53 ± .94 vs 1.94 ± .80, $p < .001$), and return-to-play (3.13 ± .78 vs 2.37 ± .82, $p < .001$). **Conclusions:** All coaches noted high levels of importance regarding concussion recognition and management. Club swim coaches with prior formal concussion education did have higher perceived knowledge and confidence in their knowledge, suggesting the benefit of concussion education even when all state laws do not require education for club sports coaches.

Sport-Related Concussion Knowledge and Reporting Behaviors Among Collegiate Club Sport Athletes

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Context: General sport-related concussion (SRC) knowledge and reporting behaviors of youth and high school athletes exists, but there is limited research on collegiate club sport athletes. Injuries in collegiate club sports are largely self- and peer-identified as there is limited consistent sports medicine coverage. **Objective:** To determine the level of SRC knowledge and reporting behaviors among collegiate club sport athletes. **Design:** Cross-sectional study. **Setting:** Paper/pencil and web-based survey. **Patients or Other Participants:** Out of 2358 recruited athletes, a total of 410 collegiate club sport athletes responded (male: n = 247,60.5%; female: n = 163,39.5%), resulting in a 17.4% response rate. Athletes were recruited from traditional (i.e., NCAA sanctioned sports) and non-traditional (i.e., boxing, cheerleading, cycling, ice skating, martial arts, quidditch, rugby) club sports. Freshmen (28.5%), sophomore (27.3%), junior (19%), senior (21.5%), and graduate (3.2%) collegiate club athletes were included in the study. **Interventions:** Participants completed a 5-10 minute paper/pencil or online survey adapted from a previously published survey including a demographic section, a 43-item SRC-knowledge scale, and a 12-item SRC-reporting behavior scale. Recruitment occurred via an informative e-mail to collegiate club sport coaches and student team presidents. Data was collected at team meetings and via an e-mailed weblink. **Main Outcome Measures:** SRC knowledge was represented by the frequency of correct identification of common symptoms, complications related to multiple SRCs, and general SRC knowledge items. Frequencies were also calculated for each SRC-reporting behavior item in order to determine the most common reasons why club sport athletes do not report concussive injuries. **Results:** The overall mean SRC knowledge score for the sample was 36.49 ± 4.1 points out of a possible 43 points. The mean symptom recognition score was 23.01 ± 3.19 out of a possible 29 points. Headache (n = 380,92.7%), confusion (n = 377,92.0%), sensitivity to light (n = 370,90.2%), and loss of consciousness (n = 369,90.0%) were among the most commonly recognized symptoms of concussion. The most common reasons for not reporting a SRC by our club sport sample were that the athlete did not think it was serious enough (n = 166,40.5%), they did not want to lose playing time (n = 128,31.2%), and they did not know at the time it was a concussion (n = 94,22.9%). **Conclusions:** The collegiate club sport sample had similar levels of symptom knowledge compared to previous findings in different athletic settings. Fear of losing playing time was a common reason for not reporting concussive injury across demographics. Contrastingly, pressure from coaches to continue play was not as apparent in collegiate club sport compared to previous investigations in other athletic levels. Due to the self-governing nature of collegiate club sports, further research is needed in order to develop a SRC education and management plan specifically for this population of athletes.

Measurement Properties of the Balance Error Scoring System (BESS) Component of the C3 Logix Concussion Assessment Battery

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Context: Multiple domains are required to assess various aspects of brain function following concussion, including balance. The BESS was developed to provide clinicians with a portable means to assess balance when a force plate is not available. The accelerometer and gyroscope in Apple's iPad provide a validated, portable, objective measure of postural stability during BESS testing using the C3 Logix application. Although validated, other measurement properties must be established. **Objective:** To determine test-retest reliability, practice effects, and relationship of the C3 Logix BESS test to BESS errors. **Design:** Repeated-measures. **Setting:** Controlled laboratory. **Patients or Other Participants:** 38 healthy, NCAA athletes (20 females, 18 males, age = 20.1 ± 1.4 years, height = 166 ± 18.5 cm, mass = 71.3 ± 12.6 kg). **Interventions:** Participants completed four, 6-stance BESS tests across two sessions, separated by 1 week. The independent variable tested was time (within or between test sessions). Stances included double-leg (DL), single-leg (SL) and tandem stance (TS) on both firm and foam surfaces. A belt secured the iPad over the sacrum. **Main Outcome Measures:** Dependent variables included BESS errors and iBESS volume, a mathematical representation of combined accelerations in the anterior-posterior, medial-lateral and rotational planes. Intraclass correlation coefficients (ICC) were calculated for BESS errors and iBESS volume to determine within-session and 1-week test-retest reliability. A repeated-measures analysis of variance (ANOVA) and paired samples t-tests post-hoc analysis were used to determine differences between BESS errors and iBESS volume over time. Pearson correlation was used to assess the relationship between BESS errors and iBESS volume. **Results:** Across test conditions, within-session reliability ranged from acceptable to excellent for errors (ICC(2,1) = 0.76-0.93, P < .001) and was excellent for iBESS volume (ICC(2,1) = 0.92-0.97, P < .001). One-week test-retest reliability was acceptable for errors (ICC(2,1) = 0.80 (95% CI: 0.62-0.90, P < .001) and excellent for iBESS volume (ICC(2,1) = 0.91 (95% CI: 0.82-0.95, P < .001). ANOVA revealed a significant difference (P < .05) between errors and iBESS volume over time. Post-hoc analysis revealed BESS errors were significantly higher in trial 1 (11.5 ± 5.4) compared to trials 2 (9.2 ± 4.4), 3 (8.8 ± 4.0) and 4 (8.1 ± 3.3). A significantly higher error count was also found in trial 2 (9.2 ± 4.4) compared to trial 4 (8.1 ± 3.3). Post-hoc analysis revealed iBESS volume was significantly greater in trial 1 (-5.9 ± 5.6) compared to trials 2 (-7.6 ± 5.5), 3 (-7.3 ± 5.8) and 4 (-7.5 ± 5.2). Pearson correlations revealed a significant, moderate-strong, positive relationship between errors and iBESS volume, in the SL firm (r = 0.44), TS firm (r = 0.63), TS foam (r = 0.61) and total stance (r = 0.41) conditions. **Conclusions:** Acceptable to excellent test-retest reliability was established for the C3 Logix BESS test. Compared to traditional BESS errors, iBESS volume allowed for increased within-session and 1-week test-retest reliability, a reduction of practice effects after 2 trials compared to 3, and a more sensitive measure of balance for DL stance conditions. The C3 Logix BESS test may provide clinicians with a more reliable and sensitive assessment of balance compared to the traditional BESS test.

Validity and Reliability of Select Neurocognitive Tests of the C3 Logix Concussion Assessment Battery

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Context: Appropriate management of sport-related concussion relies on the clinical examination, while objective measurements are also recommended. The C3 Logix (C3) application offers a suite of concussion tests including neurocognitive tests that represent touch-screen adaptations of gold-standard paper-pencil tests. We were unable to identify published studies that established validity or reliability of the iPad versions of these neurocognitive tests. **Objective:** To assess the concurrent validity and one-week test-retest reliability of Trails A (TA), Trails B (TB), and Symbol Digit Modality Test (SDMT) available through C3. **Design:** Repeated-measures. **Setting:** Controlled laboratory. **Patients or Other Participants:** 38 healthy NCAA athletes (20 females, 18 males; age = 20.08 ± 1.44 years, height = 166 ± 18.5 cm, mass = 71.3 ± 12.6 kg). **Interventions:** Participants completed two test sessions (S1, S2), one week apart. Test sessions included administration of C3TA, C3TB, C3SDMT, and analogous paper-pencil tests. The order of test administration was randomized in two ways: whether C3 or paper-pencil tests would be taken first and whether Trails A/B or SDMT test would be taken first. Testing order was consistent between sessions with a five-minute break between C3 and paper-pencil tests. **Main Outcome Measures:** Independent variables included time to completion (seconds) for TA and TB

and number of correctly matched pairs for SDMT. The dependent variable was the test session. Validity was assessed using Pearson correlations comparing the results of C3 and paper-pencil tests. One-week reliability was assessed using Intraclass Correlation Coefficients (ICC) comparing scores earned on C3 during week one and week two. Student T-tests were calculated to determine practice effects between sessions. **Results:** C3TA times (S1 = 17.51 ± 3.92, S2 = 15.81 ± 3.38) demonstrated weak correlation (r = .0.122 p = 0.472) compared to paper-pencil times (S1 = 17.20 ± 3.92, S2 = 15.57 ± 3.61). C3TB times (S1 = 35.41 ± 6.77, S2 = 29.90 ± 6.30) showed a moderate correlation (r = .519, p = 0.001) when compared to the paper-pencil test (S1 = 40.04 ± 9.08, S2 = 33.96 ± 7.15). C3SDMT matched pairs (session 1: 70.51 ± 9.17, session 2: 74.11 ± 10.65) demonstrated a very strong correlation (r = .715, p < 0.01) with paper-pencil results (S1 = 68.41 ± 8.09, S2 = 74.41 ± 10.01). One-week test-retest reliability was moderate to strong for C3TA, (ICC(2,1) = 0.543, 95% CI [0.113-0.765] ,C3TB (ICC(2,1) = 0.862, 95% CI [0.732-0.929]), and C3SDMT tests (ICC(2,1) = 0.904, 95% CI [0.814-0.951]. Student t-tests showed a significant difference between test session one and two for all tests (p < 0.05). **Conclusions:** Assessment of C3 Logix neurocognitive tests shows mixed support for their concurrent validity. Further testing will need to be conducted to construct validity. C3TB and SDMT tests demonstrated a strong correlation to their paper-pencil analogs, while C3TA provided poor concurrent validity. Reliability of the tests over the one-week period was moderate for C3TA and C3TB, and excellent for SDMT. Clinicians should be aware of the practice effect between session one and two, and mindful of the lack of memory tests within C3 Logix when making return to play decisions for concussed athletes.

Repeat Administration of the SWAY Balance Mobile Application Elicits a Practice Effect

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Context: Several balance assessment techniques are used pre- and post-concussion to track patient progression. The ability to provide quantitative measures of balance is necessary, however because of the size, complexity, and cost of equipment these assessment techniques tend to be limited to the research setting. This has led to the development of smartphone balance applications to assess balance efficiently and quickly in the clinical setting. However, many of these applications have limited research supporting their efficacy. **Objective:** To assess if repeated administration of the SWAY Balance Mobile Application (SWAY Medical, Tulsa, OK) demonstrates a practice effect in high school football athletes. **Design:** Repeated measures. **Setting:** High school gymnasium. **Patients or Other Participants:** Thirty-five healthy male football players (15.7 ± 1.17 years, 173.8 ± 11.7 cm, 82.3 ± 22.7 kg) volunteered. Individuals who had sustained a concussion during the season were excluded. **Interventions:** All participants completed the SWAY Balance Mobile Application five times. The time points included three measures on the same day at pre-season, one test 49 days post the pre-season bout (midseason), and one 21 days post the mid-season test (post-season). The SWAY Balance Mobile Application provides a score (0-100) with 100 indicating perfect balance for five stances (feet together, tandem right, tandem left, single-leg right, single-leg left) and an overall score. **Main Outcome Measures:** The dependent variables are SWAY Mobile Balance score for feet together, tandem right, tandem left, single-leg right, single-leg left, and overall. The independent variable is time with five time points (pre-season one, pre-season two, pre-season three, mid-season, and post-season). A multivariate repeated measures ANOVA was conducted. Follow up one-way repeated measures ANOVA's were conducted if the multivariate test was significant. The alpha level was set a priori at p<0.05 for all analyses. **Results:** The multivariate repeated measures ANOVA was significant for time (F = 5.285, p < 0.001). For the follow up one-way repeated measures ANOVA's the overall score, single-leg left, single-leg right variables were significant for time (p < 0.001). Specifically, for the overall score at time three, scores had plateaued and were no longer significantly different from the previous time point (61.65 ± 9.72, 71.22 ± 9.88, 74.91 ± 7.07, 75.81 ± 6.21, and 74.42 ± 6.75). The same results were seen for the single-leg right stance (29.03 ± 5.59, 42.13 ± 5.91, 44.01 ± 7.27, 45.13 ± 6.92, and 44.48 ± 5.79) and single-leg left stance (33.21 ± 6.53, 45.65 ± 4.09, 46.41 ± 5.53, 49.41 ± 5.59, and 47.12 ± 5.94). **Conclusions:** Our results revealed no practice effect for the easier balance conditions (feet together, tandem right, and tandem left) for the SWAY Balance Mobile Application. However, a practice effect was seen for the single-leg right, single-leg left, and overall scores. By time point three no significant improvements were made. Clinicians must realize the potential for practice effects when administering the SWAY Application; it may be necessary for up to three completions to negate any practice effects.

Are Institutionally-Based Normative Values for ImPACT Scores Different Than Manufacturer-Provided Normative Values?

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Context: The pre-injury (baseline) computerized neurocognitive assessment has been recommended by several governing health care bodies. Recently, the value of the baseline assessment has been questioned given the availability of normative data. Normative data has been suggested as a replacement for the less time- and cost-effective baseline assessment. The Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT) battery provides users the ability to compare their athletes' neurocognitive performance against baseline values as well as manufacturer-provided (MP) normative values. It is unknown whether these MP normative values are representative of individual institutions. **Objective:** To compare ImPACT's MP normative values to institutionally-based (IB) normative values. **Design:** Descriptive. **Setting:** Laboratory. **Patients or Other Participants:** Division I varsity athletes (n = 777) from 22 different sports. **Interventions:** Prior to the start of the sport season, all participants were administered ImPACT as part of their institution's sport concussion management policy. Those with at least one outcome score below the 16th percentile were re-tested up to two more times to obtain optimal measurement of their true ability. Participants were divided into four sub-population groups based on the ImPACT's normative tables: males < 18 years old (YM, n = 112), females < 18 years old (YF, n = 100), males > 19 years old (OM, n = 337) and females > 19 years old (OF, n = 228). **Main Outcome Measures:** Comparisons were made between MP and IB Verbal (VER) and Visual (VIS) Memory, Visual Motor Speed (VMS) and Reaction Time (RT) outcome scores for all groups. Participant raw data were manually reviewed to create percentile ranks. IB raw scores were compared to the MP normative values using a Chi-squared goodness of fit analysis. Five bins were created using the MP percentile ranks and matching raw data. The Chi-squared analyses observed the probability that IB (observed) raw scores fit within the same bin as was allocated to the MP (expected) raw scores. **Results:** Based on 4 degrees of freedom, the Chi-squared analyses showed significant differences between raw score allocation for all VER, VIS, VMS and RT outcome scores in all groups. YM-VER ($\chi^2 = 136.1$, $p < 0.001$), -VIS ($\chi^2 = 73.4$, $p < 0.001$), -VMS ($\chi^2 = 366.3$, $p < 0.001$) and -RT ($\chi^2 = 90.5$, $p < 0.001$). YF-VER ($\chi^2 = 52.1$, $p < 0.001$), -VIS ($\chi^2 = 176.5$, $p < 0.001$), -VMS ($\chi^2 = 345.1$, $p < 0.001$) and -RT ($\chi^2 = 84.1$, $p < 0.001$). OM-VER ($\chi^2 = 222.5$, $p < 0.001$), -VIS ($\chi^2 = 49.5$, $p < 0.001$), -VMS ($\chi^2 = 876.5$, $p < 0.001$) and -RT ($\chi^2 = 152.4$, $p < 0.001$). OF-VER ($\chi^2 = 130.5$, $p < 0.001$), -VIS ($\chi^2 = 121.1$, $p < 0.001$), -VMS ($\chi^2 = 366.3$, $p < 0.001$) and -RT ($\chi^2 = 136.4$, $p < 0.001$). **Conclusions:** Our results indicate a disparity between MP and IB normative values. These findings elucidate the need to create IB normative data sets that are representative of its student-athletes when baselines are not utilized. Caution is warranted when using MP normative values for clinical-decision making in the absence of a baseline assessment.

Evaluation of Domain and Factor Structure of CNS Vital Signs

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Context: Computerized neurocognitive testing is a popular tool employed in evaluating concussion. This testing purports to measure underlying cognitive constructs such as attention, working memory and executive function, and combines these outcomes into cognitive domain scores representing arithmetic combinations of individual test modules. Identifying the influence of latent cognitive factors on the measured outcomes would allow for comparing results across multiple testing platforms and simplify clinical interpretation. **Objective:** To test the existing domain structure of the CNS Vital signs computerized neurocognitive battery and identify its latent factor structure. **Design:** Secondary data analysis. **Setting:** Clinical research center. **Patients or Other Participants:** 264 (age = 19.0 ± 0.9 yrs) Division I college athletes. **Interventions:** Participants completed an uninjured preseason baseline computerized neurocognitive assessment. **Main Outcome Measures:** Valid CNS Vital Signs' raw test scores (immediate/delayed Verbal Memory, immediate/delayed Visual Memory, Finger Tapping, Symbol Digit Coding, Stroop Test, Shifting Attention, and Continuous Performance) and standardized domain scores (Composite Memory, Psychomotor Speed, Reaction Time, Complex Attention, Cognitive Flexibility, Executive Function, Processing Speed, and Neurocognitive Index) were collected. A principal component analysis and exploratory factor analysis were performed to examine how to group scores into clinically logical constructs. **Results:** The principal component analysis of standardized domain scores extracted three components broadly representing attention, processing speed, and memory, which account for 73.9% of the variance across all domains. An

exploratory factor analysis was conducted on the raw test scores to compare the existing domain structure with the underlying latent cognitive constructs. Based on a scree plot, proportion of variance explained (15%-59%), and interpretability, a four-factor solution was selected representing executive functioning, memory, processing speed, and attention. Several items measuring commission and omission errors loaded poorly across multiple factors. The simple attention test cross-loaded on both the executive functioning and attention factors, but all other cross-loadings were small ($\beta < 0.25$). **Conclusions:** The results of our component and factor analyses suggest CNS Vital Signs' domain scores may be broadly grouped into three categories representing attention, memory and processing speed. Using the single Neurocognitive Index may not be appropriate. An exploratory factor analysis of the raw test module scores identified four cognitive constructs reflecting motor speed, memory, executive functioning, and attention. These factors demonstrated results that are difficult to reconcile with the current domain structure. While the memory and motor speed factors align almost exactly with two of the existing domains, the others suggest that redefining the domains with an alternate statistical approach may clarify the areas of cognition being assessed for more accurate interpretations by clinicians. Further clarification and confirmation of the domains, latent factors and summary indices may result in better evaluation of the sensitivity and clinical usefulness of this and other computerized neurocognitive test platforms.

Test-Retest Reliability of a Computerized Measure of Postural Stability in High School Athletes

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Context: The balance error scoring system (BESS) is a common balance assessment performed prior to- and following sport concussion (SC) evaluation. The BESS has been demonstrated to have variable reliability and validity. Computerized clinical measures of balance have been developed in order to reduce the subjectivity of the BESS and improve its test-retest reliability. **Objective:** To examine the test-retest reliability of the Bertec Sport Advantage (BSA) computerized balance system and investigate the relationship between the number of errors committed on the BESS and the amount of postural sway. **Design:** Prospective cohort study. **Setting:** High school athletic training clinic. **Patients or Other Participants:** Participants included 33 student-athletes (16 males, 17 females) who were assessed at two time points approximately one year apart. Participants had an average height of 166.7 ± 8.49 cm and 170.0 ± 7.32 cm at time points 1 and 2, respectively. **Interventions:** As part of the high school's concussion management policy, all participants completed the BESS during pre-season baseline testing. For the current study, participants completed the BESS while standing on the BSA, which measured postural sway via center of pressure analysis. Each assessment was administered by the same rater at both time points. **Main Outcome Measures:** Paired t-tests were used to assess differences across time for the number of BESS errors committed and postural sway for each BESS trial and composite score across time points. Two-way mixed intraclass correlation coefficients ($ICC_{(3,1)}$) were calculated between time points with 95% confidence intervals for each outcome measure. Pearson correlation coefficients were used to examine the relationship between postural sway and the number of counted errors committed per BESS trial and the composite score at each time point. All analyses were performed with $\alpha = .05$. **Results:** Time points 1 and 2 were separated by an average of 367.2 ± 32.80 days. Participants committed significantly fewer errors ($p < .01$) at time point 2 (12.9 ± 4.91) compared to 1 (17.4 ± 6.05). Postural sway composite scores (T1 = 2.79 ± .52; T2 = 2.73 ± .67; $p = .63$) were not significantly different between time points. A significant correlation between the number of BESS errors and postural sway was observed at time point 1 ($r = .50$, $p < .01$) but not at time point 2 ($r = .18$, $p = .34$). Weak ICCs were observed between time points for the BESS (ICC = .28; CI = -.07, .57) and BSA (ICC = .35; CI = .01, .62) composite scores. **Conclusions:** Our results demonstrate weak test-retest reliability of the BESS and BSA over a one-year test-retest interval which are potentially due to practice effects and motor skill development associated with age. Our findings support annual baseline assessment of balance for adolescent athletes. Additional research is warranted to establish the test-retest reliability of the BSA in a collegiate athlete sample.

A Comparison of King-Devick Test Baseline Scores Between English-Speaking and Spanish-Speaking High School Athletes

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Context: The King-Devick Test (KD) is a rapid number naming assessment that is intended to screen for sport-related concussion (SRC), and normative data for the KD are available for age and sport but the only test language for the KD is English. Approximately 19% of high school athletes in the U.S. identify as Hispanic and no study to date has compared baseline KD performance between native English-speaking high school athletes and native Spanish-speaking high school athletes. **Objective:** To compare baseline KD performance between native English-speaking high school athletes and native Spanish-speaking high school athletes. **Design:** Retrospective cohort. **Setting:** A large cohort of high schools in the south. **Patients or Other Participants:** Participants included 76 native Spanish-speaking athletes (58 male, 18 female, age: 15.40 ± 1.30 years) and 76 native English-speaking athletes (58 male, 18 female, age: 15.4 ± 1.3 years). These groups were matched on age, sex, and sport. Seven percent (6/82) of native Spanish-speaking high school athletes reported a history of SRC, learning disability, and/or hyperactivity disorder and were excluded from this study. **Interventions:** All athletes completed a baseline KD and neurocognitive assessment that included a demographics section assessing native language. All athletes were administered the KD in English by an English-speaking researcher. **Main Outcome Measures:** The fastest time (seconds) of two error-free trials on the KD test were used as the main outcome measure. Between-group differences were compared for baseline KD time with an independent samples t-test. Level of statistical significance was set at $p < .05$. **Results:** Native Spanish-speaking high school athletes performed significantly slower (47.27 ± 8.95 sec) on the KD test compared to native English-speaking athletes (35.47 ± 5.83 sec) ($t(150) = 9.64$, $p < .01$). **Conclusions:** These results agree with previous literature examining native language differences on test performance. Other commonly used SRC assessments, such as neurocognitive testing, offer alternative language versions with separate normative data. However, the KD is only offered in English and normative data for Spanish-speaking athletes are not available. Normative data and alternative test versions for athletes endorsing Spanish as their native language should be developed for the KD test.

Test-Retest Reliability and the Effects of Exercise on the King-Devick Test

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Context: The King-Devick (K-D) Test is theorized to evaluate saccadic eye movement and visual dysfunction following a sport concussion. Clinical sideline assessments must prove to be reliable over time to allow repeated measurements and robust to the effects of exercise to allow for utilization in an athletic clinically setting. **Objective:** To determine the test-retest reliability using a two-week test-retest interval and the effects of exercise on K-D Test performance. **Design:** Crossover. **Setting:** Laboratory. **Patients or Other Participants:** Sixty-three (39 females, 24 males) healthy, recreationally active college students (age = 21.0 ± 1.5 years) and no history of concussion within 6-months of study enrollment participated in the current study. **Interventions:** Participants completed two testing sessions separated by a two-week test-retest interval. At each visit, subjects were administered the K-D test prior to and following the intervention. The K-D test was administered in accordance with manufacturer instructions. The intervention consisted of a 30-minutes of rest or a standardized exercise protocol which consisted of five minute increments of treadmill walking, squat jumps and lateral hops. Participants were counterbalanced to either complete the rest or exercise intervention at each time point. Participant effort was self-reported based on Borg's Rated Perceived Exertion scale which was recorded after each five-minute cycle. **Main Outcome Measures:** Intraclass correlation coefficients ($ICC_{2,1}$) with 95% confidence intervals were used to assess the test-retest reliability of the total completion time (seconds [s]) of the three K-D test cards between times points 1 and 2. The effects of the interventions on K-D time were evaluated using a repeated measure 2x2

ANOVA (intervention x time) with post-hoc paired t-tests and Cohen's-d effect sizes. **Results:** The K-D Test was observed to have strong reliability between time points ($ICC_{2,1}$ = 0.90 [0.71, 0.96]) with a completion time of 38.5 ± 5.70 s and 38.4 ± 5.80 s (p = .91) prior to intervention at time points 1 and 2, respectively. There was no significant intervention x time interaction (p = .55) or intervention main effect (p = .68) on K-D Time; however, a significant time main-effect (p < .001) was observed. K-D time significantly decreased (p < .001, d = -0.29 [-.64, .06] from baseline (38.4 s ± 5.80) to post-exercise (36.7 ± 6.00 s) and baseline (38.5 s ± 5.70 s) to post-rest (37.0 s ± 5.30 s). No significant differences were observed for K-D time between time points 1 (37.0 ± 5.30 s) and 2 (36.7 ± 6.00 s) post-intervention (p = .52). **Conclusions:** The K-D Test was demonstrated to have strong test-retest reliability in recreationally active, healthy young adults and was robust to the effects of a systematic exercise protocol. K-D time was significantly improved following both interventions; however, the magnitude of change was a small effect-size and may not be clinically relevant.

Free Communications, Poster Presentations: Factors Influencing Concussion Baselines

George R. Brown Convention Center, Hall C; Tuesday, June 27, 10:00AM-5:00PM; Wednesday, June 28, 10:00AM-5:00PM; Thursday, June 29, 10:00AM-1:00PM

Authors present June 27: Peer Review Authors – Last Names A through M: 10:30AM-11:15AM; Peer Review Authors – Last Names N through Z: 11:15AM-12:00PM

Influence of Self-Reported Fatigue and Sex on Concussion Baseline Assessment Scores

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Context: Concussion baseline assessments are advocated to provide an objective pre-injury point-of-comparison for determining the extent of post-concussion neurological deficits, and to assist with return to activity decision-making. Many factors, including testing environment, proctor availability, and testing group size, can influence test accuracy and validity; however, it is unknown how self-reported fatigue affects test scores. **Objective:** To investigate the influence of self-reported fatigue on concussion baseline assessment scores. **Design:** Cross-sectional. **Setting:** Clinical research center. **Patients or Other Participants:** Participants included 494 healthy Division I college student-athletes (220 females, 274 males, age = 19.96 ± 1.26 yrs). **Interventions:** During preseason baseline testing, participants were asked to rate his or her fatigue on a scale from 0 to 100 based on how they normally feel and function each day, with 0 being completely exhausted and 100 being completely awake and alert. **Main Outcome Measures:** Each participant completed a multi-modal concussion baseline assessment including a graded symptom checklist (number of symptoms endorsed, and total symptom severity score), Standardized Assessment of Concussion, Balance Error Scoring System, and CNS Vital Signs computerized neurocognitive testing. Multiple linear regressions were calculated to predict concussion baseline examination scores from self-reported fatigue. **Results:** Self-reported fatigue level and sex were significant predictors of total symptom severity score ($F_{3,490} = 33.62$; $P < 0.001$; $R^2 = 0.17$). Total symptom severity scores decreased 1 point for every 10-point increase in alertness, and females reported 1.84 points higher on total symptom severity scores compared to males. Critically, the effect of sex on graded symptom checklist total symptom severity score significantly depends on self-reported level of fatigue ($t = 2.78$; $P = 0.006$), with the greatest effect of sex observed when fatigue is highest. We also observed main effects of self-reported fatigue and sex on the number of symptoms endorsed ($F_{3,491} = 27.04$; $P < 0.001$; $R^2 = 0.14$), such that fatigued ($t = 4.91$; $P < 0.001$) and female ($t = 3.92$; $P < 0.001$) student-athletes reported a greater number of symptoms. We did not observe any significant findings for any of the other multi-modal assessments ($P > 0.05$ for all). **Conclusions:** Our results indicate main effects of self-reported fatigue and sex, as well as a significant sex-by-fatigue interaction, on total symptom severity scores. When males and females are awake and alert, they report similar total symptom severity scores; however, when fatigued, females report significantly higher total symptom severity scores. This underscores that fatigue differentially affects subjective symptom reporting for males and females. Using total symptom severity scores as part of the post-injury management is a common practice. Our data suggest that fatigue is a necessary factor to consider in the interpretation of total symptom severity scores. Self-reported fatigue also affected total number of symptoms endorsed, but did not adversely affect other components of our multi-modal concussion assessment paradigm (Standardized Assessment of Concussion, Balance Error Scoring System, or CNS Vital Signs).

Association Between Baseline Symptom Severity and Sensory Organization Function in College Athletes With and Without a Concussion History

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Context: Sensory organization and integration is affected following sport-related concussion, which often contributes to prolonged symptom presence. However, the length of this impairment is unknown. Few studies have examined the relationship between previous concussion history and baseline symptom cluster severity. **Objective:** To examine the associations between symptom severity (total overall and by cluster) and sensory organization during a dynamic posturography task in college athletes. Symptom clusters examined were categorized as 1) vestibular-somatic (headache, nausea/vomiting, balance problems, dizziness, neck pain, and pressure in head), 2) sleep-arousal (fatigue, trouble falling asleep, and drowsiness), 3) cognitive-sensory (light sensitivity, noise sensitivity, feeling slowed down, fogginess, difficulty concentrating, confusion, and vision problems), and 4) affective (irritability, sadness, nervousness/anxiousness, feeling more emotional, and don't feel right). A secondary purpose was to examine correlations between individual symptom severity metrics and sensory organization. **Design:** Cross-sectional. **Setting:** Clinical research center. **Patients or Other Participants:** Two hundred thirty-two NCAA Division I athletes (151 males, 81 females, age = 19.3 ± 0.9 yrs). **Interventions:** During standardized baseline testing, participants completed a graded symptom checklist, demographic questionnaire, and a Sensory Organization Test

(SOT). **Main Outcome Measures:** The SOT Composite and three ratio scores (Vestibular, Visual, Somatosensory) served as the primary outcomes. Separate linear regression models for each SOT outcome investigated the association between total symptom severity and each SOT score. Similarly, multivariable association between all four symptom clusters and each SOT outcome were also investigated (with history of concussion as a covariate). Pearson correlations examined associations between individual symptom severities and SOT outcomes. Alpha level was set to $P < 0.05$ *a priori.* **Results:** In the total sample, 47 (20.3%) were football athletes, and 55 (24.0%) reported a concussion history. There was not a statistical difference for every 10-point increase in total symptom severity and SOT Composite scores (Beta = -1.4: 95% CI = -2.9, 0.1). Although not statistically significant, the SOT Composite (Beta = -0.8; 95% CI: -1.6, 0.0) and Vestibular (Beta = -1.2; 95% CI: -2.3, 0.0) scores were lower when sleep-arousal symptom cluster severity was higher. There was a significant, but weak correlation between baseline drowsiness severity and SOT Composite (r = -0.211; P = .001) and Vestibular (r = -0.165; P = .013) scores. No other correlations between individual symptom severity scores and SOT outcomes were observed ($P > 0.05$). **Conclusions:** Athletes with greater sleep-arousal symptom cluster severity scores, specifically "drowsiness", may have lower sensory organization scores at baseline. Clinicians should be mindful of the relationship between baseline symptom presentation and other metrics when interpreting baseline scores. Future research should continue to examine the relationships between symptom presentation types and sensory organization post-concussion and how changes in post-injury symptom presentation may affect such outcomes.

The Reliability and Concurrent Validity of the kBESS

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Context: The Balance Error Scoring System (BESS) has been demonstrated to have variable reliability which is partially due to the subjective nature of its scoring. Computerized measures of the BESS may increase its objectivity and reliability. **Objective:** To examine the reliability and the concurrent validity of the Kinect Balance Error Scoring System (kBESS). **Design:** Repeated measures. **Setting:** Laboratory. **Patients or Other Participants:** Sixty-five healthy subjects (24 males and 41 females, age = 21.0 ± 1.5 years, height = 170.6 ± 11.2 cm) participated in the current study. **Interventions:** Participants completed the BESS at two time points separated by two weeks. A Kinect sensor was used to record a 2-dimensional video. Custom software calculated the number of errors per trial and the BESS composite score. To examine concurrent validity, two blinded-raters scored the BESS videos (composite and errors per trial) recorded with the custom software. **Main Outcome Measures:** Intraclass correlation coefficients (ICC) were used to calculate intrarater, interrater and test-retest reliability for human raters and the kBESS for each BESS trial and the composite score. Pearson correlation coefficients were used to calculate concurrent validity between the kBESS and human raters based on BESS trial and composite score. Independent and paired t-tests were used to assess for significant differences between raters and across time. All analyses were performed with $\alpha = .05$. **Results:** For the BESS composite score, human raters were observed to have strong intrarater ($ICC_{(3,1)} = 0.91$) between time points 1 (17.6 ± 8.27 errors) and 2 (20.4 ± 7.82 errors). Raters 1 and 2 were observed to have strong interrater reliability ($ICC_{3,1} = 0.76$) at time point 1 with 18.5 ± 5.87, and 14.7 ± 5.99 errors counted, respectively ($p < 001$). Strong test-retest ($ICC_{3,1} = 0.85$) reliability for human raters with 15.6 ± 6.00 errors and 14.1 ± 5.64 errors counted at each time point ($p = .004$). The kBESS was observed to have moderate test-retest reliability ($ICC_{3,1} = 0.50$) with 13.1 ± 4.57 errors and 12.1 ± 5.18 errors counted at each time point ($p = .10$). In terms of concurrent validity weak to moderate correlations (r = 0.19 - 0.67) were observed between the kBESS and human raters for each trial and weak correlations were observed at time points 1 and 2 for the BESS composite score (r = 0.39). **Conclusions:** As a novel measure of postural stability, the kBESS was observed to have moderate reliability and weak concurrent validity when compared to human raters. Further refinement of the kBESS algorithm is necessary to improve its test-retest reliability. Until the kBESS meets the requite criteria for clinical utility, clinicians should consider ways to improve intra- and interrater reliability of the BESS in order to increase its clinical utility.

The Reliability of Dynamic Visual Acuity (DVA) Testing in Normal, Healthy Young Adults

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Context: Computerized dynamic posturography (CDP) technology is one method used for the objective assessment of dynamic visual acuity (DVA). The test-retest (intersession) reliability of computerized DVA assessment, however, has not been adequately demonstrated. **Objective:** The purposes of this study were to determine the reliability and validity of the Dynamic Visual Acuity (DVA) test protocol using the NeuroCom SMART Balance System. The primary aim was to determine the within-day and between day consistency (i.e. intra-rater and inter-session reliability) of the DVA test in a healthy (asymptomatic) sample; the secondary aim was to determine the concurrent validity (between the gaze stabilization and DVA test components) of the DVA testing protocol in a healthy (asymptomatic) sample. **Design:** A prospective, cross-sectional, repeated measures (test-retest) design was used to determine the intra-rater and inter-session reliability of the Dynamic Visual Acuity (DVA) test. **Setting:** University laboratory. **Patients or Other Participants:** Forty subjects were recruited for the study (25 female, 15 male, ages 23.6 ± 0.33 years, height 172.4 ± 1.8 cm). **Interventions:** Each subject completed the static visual acuity (SVA) test, perceptual time test (PTT), the DVA test, and the gaze stabilization test (GST). Testing as repeated 30 minutes later (test 2) and one week later (test 3). **Main Outcome Measures:** Test-retest reliability (ICC 2,1) was calculated for each of the outcome measures; concurrent validity between the GST and DVA tests was calculated using the Spearman Rho correlation (ρ). **Results:** The test-retest reliability was excellent for the number of incorrect responses on the GST (left direction, tests 1 and 2, r = .822, p = .0001) and LogMAR scores on SVA test (between tests 1 and 2, and tests 1 and 3; r = .775, p = .001 and r = .723, p = .0001 respectively). Good to moderate test-retest reliability was observed for DVA loss symmetry (time 1 and 3, r = .500, p = .017); LogMAR scores on DVA (right direction, time 1 and 3, r = .453, p = .032; left direction time 1 and 2, r-.568, p = .005); incorrect responses on DVA (left direction, time 1 and 3, r = .601, p = .003); and number of incorrect responses on GST (right direction, tests 1 and 2, r = .547, p = .008; left direction, test 1 and 3, r = .621, p = .002). Spearman correlation coefficients (ρ) for the DVA and GST were not significant (p > .05) when comparing loss symmetry and number of incorrect responses across test sessions. **Conclusions:** LogMAR scores on SVA test demonstrated excellent test-retest reliability among healthy young adults while DVA loss symmetry and number of incorrect responses on the DVA and GST demonstrated good-to-moderate test-retest reliability. The lack of concurrent validity between GST and DVA tests suggests that these tests measure different constructs of dynamic visual acuity.

Caffeine Alters Reaction Time of ImPACT, But Not the King Devick Test

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Context: A concussion is defined as a traumatically induced transient disturbance of the brain caused by a biomechanical force. These problematic injuries can prevent athletes from participating in physical activity for a number of days, weeks, or even months. Due to its increase in memory, mental alertness, and concentration, caffeine could potentially be utilized to improve the outcomes of post-concussion neurocognitive testing and expedite an athlete's return to play. **Objective:** To evaluate the effect of caffeine on reaction time (RT) when measured with two neurocognitive evaluation tools; Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT) or Kind-Devick (KD). **Design:** Cross-sectional **Setting:** Athletic Training Laboratory **Patients or Other Participants:** Eighteen (14 males and 4 females; Age = 21.7 ± 1.4 years; Height = 175.0 ± 9.1 cm; Mass = 75.6 ± 12.5 kg) college students participated. Exclusion criteria included a history of high blood pressure, heart condition, neurocognitive disorder, mental illness, more than one concussion or one within the last year, caffeine sensitivity, taking any prescribed medications except birth control, ingest more than 500mg of caffeine daily or have been exposed to ImPACT or KD tests within the last year. **Interventions:** Participants were randomly assigned to ingest either a caffeine (5-hour Energy®) or placebo (pink lemonade) 1.93 fl. oz. solution. Following ingestion of the intervention, participants waited 45 minutes for the solution to be absorbed in the bloodstream then began both assessments with one preceding the other in a randomized order. Follow-up testing was conducted one week later under the opposite solution with the neurocognitive testing order remaining the same. **Main Outcome Measures:** The RT score produced by ImPACT and the overall KD time were recorded and evaluated on

both testing days after ingestion of the solution. **Results:** A significant improvement was noted on the ImPACT RT score following ingestion of caffeine (0.53 ± 0.05 seconds) compared to the placebo substance (0.56 ± 0.07 seconds, p=.007, Effect Size = 0.60 (-0.07 – 1.27)). There was no significant difference between caffeine (36.2 ± 5.4 seconds) and placebo (37.6 ± 5.5 seconds) (p = .118) on KD RT. **Conclusions:** Participants were able to identify a computerized stimuli 0.03 seconds faster following ingestion of caffeine. Although ImPACTs RT reliable change index score of 0.06 seconds was not met (indicator used to determine true improvement or deficit), the improvement following caffeine for the current study is worth noting. The proposed clinical question still remains, should medical professionals inquire about caffeine intake prior to neurocognitive testing, to minimize possible threats to the evaluation process?

Head Impact Exposures and Neurologic Function in College Football and Soccer Players

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Context: The effect of repetitive head impacts on neurological function is an area of ongoing debate; however most studies investigate football. Thus, limited evidence exists on the outcomes of repetitive head impacts in other contact sports such as soccer where the head impacts are a purposeful component of the game. **Objective:** To examine the relationship between head impact kinematics and neurologic function through a clinical multifaceted testing battery over the course of one season in male collegiate football players (FB) and women's soccer players (WSOC). **Design:** Prospective longitudinal. **Setting:** Laboratory. **Patients or Other Participants:** Thirty three NCAA Division I athletes including fifteen male FB (age: 20.5 ± 1.1 years, height: 186.4 ± 7.3 cm, weight: 107.3 ± 17.1 kg) and eighteen WSOC (age: 19.4 ± 1.2 years, height: 167.6 ± 4.2 cm, weight: 61.2 ± 5.4 kg) student athletes. **Interventions:** Each participant performed a neurological testing battery prior to the start of the season and again within one week post-season including: the standardized assessment of concussion (SAC), balance error scoring system (BESS), clinical reaction time (CRT), ImPACT computerized neurocognitive exam, and King-Devick (KD) assessment. Specifically, FB athletes wore the head impact telemetry system (New Lebanon, NH.) embedded in their helmets and WSOC wore smart impact monitors (SIM-G; Triax, Norwalk, CT.) accelerometers. **Main Outcome Measures:** Performance differences from baseline to post-season where compared with repeated measures ANOVAs. A linear regression investigated head impact kinematics (number of head impacts and cumulative linear accelerations) as predictors of neurological performance changes. **Results:** Head impact kinematic means were as follows for FB (279 + 113 impacts, 23.8 + 8.0 g's mean linear acceleration, and 6,657.1 + 3,747.8 g's cumulative acceleration) and WSOC (161 + 220 impacts, 15.8 + 3.8 g's mean linear acceleration, and 2,426.8 + 1,931.2 g's cumulative acceleration). Combined head impact kinematics were not significant predictors for change in performance for BESS (Δ 3.2 fewer errors, p = 0.625), SAC (Δ0.4 point improvement, p = 0.989), CRT (Δ 0.83 ms faster, p = 0.530), KD (Δ 2.0 seconds faster, p = 0.181) or within ImPACT Verbal Memory (Δ 0.31 decrease, p = 0.607), Visual Memory (Δ 2.14 decrease, p = 0.179), Processing Speed (Δ 2.18 improvement, p = 0.299), or Reaction Time (Δ 0.01 sec decease, p = 0.988). There also were no significant predictors within sport. The only significant main effect for time was in BESS (Pre: 13.6 + 6.4 and Post: 10.3 + 5.2 errors, p = 0.015). There were no differences or predictors within soccer alone. **Conclusions:** A single FB or WSOC season was generally not associated with changes in a multifaceted neurological health screening and head impact kinematics was not predictive of changes. It is noteworthy the FB participants herein had low head impact numbers which was consistent with a limited tackling and impact team approach.

The Effect of Sex and History of Concussion on King-Devick Baseline Performance

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Context: Given that ocular dysfunction is a commonly reported visual problem in individuals with head injury, investigation into the King-Devick (KD) test and its use in sport-related concussion assessment has been a growing area. To date, little to no evidence exsists on the role that risk factors of sport-related concussion have on King-Devick outcomes, specifically in youth athletes. **Objective:** The purpose of this study was to investigate sex differences and the effect of a history of concussion on baseline King-Devick assessment in youth athletes. **Design:** This study was an experimental research design. **Setting:** The setting of this study involved field-research conducted at youth sport venues in a designated research area. **Patients or Other Participants:** A total of 468 youth athletes (307 males, 161 females), ages 8-14 years old, were recruited from mid-Michigan youth football and soccer organizations who volunteered for participation. The mean age of the subjects was 11.0 ± 1.5 years, with a mean height of 151.3 ± 12.7 cm and 98.2 ± 31.1 pounds. A total of 38 athletes (8.1%) reported a previous history of concussion. **Interventions:** The independent variables in this study were sex (male and female) along with a history of concussion (concussion history and no concussion history). Youth athletes were administered a baseline KD assessment prior to the start of their respetive season. A series of analysis of covariance (ANCOVA) statistical analyses were conducted with the *p*-value set at .05. Previous research has reported a very high reliability, with intraclass correlations of 0.97 between measurements in the absence of concussion (Galetta, Barrett, & Allen et al., 2011). The reliability of KD trials in this study at baseline revealed a good overall reliability (ICC = 0.94). **Main Outcome Measures:** The dependent variable of this study was King-Devick assessment time (seconds). To examine the effects of sex and history of concussion on KD performance, a series of ANCOVA statistical analyses were conducted, with age as a covariate. **Results:** The results of this study revealed a significant difference between sex ($p < .001$), with female youth athletes ($M = 50.74$s, $SD = 11.22$) producing faster reading times than male youth athletes ($M = 56.20$s, $SD = 11.27$). In regard to history of concussion, no significant difference ($p = .100$) was reported between groups (No history of concussion [$M = 48.88$s, $SD = 10.46$]; history of concussion [$M = 52.11$s, $SD = 10.44$]). **Conclusions:** Female youth athletes produced significantly faster times on the KD test than male youth athletes, however, however there were no differences between individuals with a history of concussion. With increasing implementation of concussion screening tools, into concussion diagnosis and management protocols, it is imperative to understand how individuals perform at baseline, and any associations between sex and history of concussion.

C3Logix and Measuring Stick Drop Test Correlation of Clinical Reaction Times and Predictors of Concussion

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Context: The increasing sport participation at the secondary level has influenced the impact of clinical tools for concussion assessment. Multiple methods of concussion assessments are available and utilize different factors such as a reaction time. Reaction time parameters may also be utilized as a predictor of sustaining a concussion. **Objective:** This study correlated the reaction time constructs of two concussion assessment tools as well as the ability to use reaction time as a predictor of sustaining a future concussion. **Design:** Randomized clinical trial. **Setting:** Two secondary schools. **Patients or Other Participants:** One-hundred fifty, males (age 14.22 ± 0.55 years; Height: 167.1 ± 2.8 cm; Weight: 69.7 ± 19.7 kg) who are participating in athletics at the secondary school level. **Interventions:** Randomized baseline concussion assessment reaction time scores were analyzed from: 1) Measuring Stick Drop Test that assessed how far a standard measuring device would fall prior to the athlete catching it that was calculated into reaction time using a standard algorithm, and 2) Baseline reaction time from the C3 Logix tablet-based assessment. The incidence of diagnosed concussion was also collected prospectively in the same population over the course of a competitive football season. **Main Outcome Measures:** A Pearson product-moment coefficient of correlation measured the relationship between the reaction time of the Measuring Stick Drop Test and reaction time of the C3 Logix test. Multiple linear regression was utilized to analyze the predictive values of reaction time and the likelihood of sustaining a concussion. **Results:** A significance ($p < 0.001$) large correlation ($r = 0.46$) was found between the Measuring Stick

Drop dominant extremity (199.7ms) and non-dominant extremity tests (201.6ms). A significance ($p < 0.001$) large correlation ($r = 0.53$) was found between the C3 Logix System Choice (416.6ms) and Simple tests (293.6ms) reaction times. A significance ($p = 0.001$) moderate correlation ($r = 0.26$) was found between the Measuring Stick Drop Dominant extremity test (199.7ms) and C3 Logix Choice (416.6ms) reaction time. A significance ($p = 0.045$) moderate correlation ($r = 0.16$) was found between and the Measuring Stick Drop Non-Dominant extremity test (201.6) and C3 Logix Choice test (416.6) reaction time. There were no significant regression results between the reaction time tests of both combined tests ($p = 0.11$), C3 Logix ($p = 0.052$), and Measuring Stick Drop ($p = 0.57$) as a predictor of the incidence of a concussion, although the C3 Logix system had a higher predictive percentage than the Measuring Stick Drop Test. **Conclusions:** Findings indicate that C3 Logix and the Measuring Stick Drop test both have applied utility for assessing reaction time testing in the clinical setting for young athletes. While a comprehensive multifactorial concussion assessment is advocated, the Measuring Stick Drop Test is practical and comparable to the C3 Logix in the measuring reaction time aspect of a concussion assessment.

Functional Reaction Time Following Concussion

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Context: Reaction time is increased following concussion, and is often measured using computer-based assessments. However, these computer-based clinical measures may not accurately reflect sport-specific reaction times necessary for high level sports performance. Thus, functional reaction time measures may be a more likely indicator of reaction time impairments induced following concussion. **Objective:** To compare functional reaction time between previously concussed and control participants. **Design:** Case-control. **Setting:** Laboratory. **Patients or Other Participants:** Participants with a concussion history (n = 15, median time since concussion = 126 days [range 28-432 days]) were matched by age (±1 year), mass (±10%), and height (±5%) to control participants (n = 15). **Interventions:** Participants performed jump landings (5 trials), anticipated cuts (5 trials each direction), and unanticipated cuts (10 total trials) following a visual cue. **Main Outcome Measures:** Using high-speed motion capture equipment, reaction time was defined as the time from a visual stimulus onset to sacrum movement ±3 cm in either the sagittal or transverse plane (whichever occurred first) to account for different movement strategies between participants. Reaction time cost was calculated by subtracting jump landing reaction time from cutting reaction time (calculated separately for anticipated and unanticipated cuts), then dividing by jump landing reaction time. This allowed for comparison between groups after standardizing for individual participant performance during the simplest task (jump landing). Positive values for reaction time cost indicate worse reaction time during cut trials as compared to jump landing trials (negative values indicated better performance during cut trials). Mixed model ANCOVA was used to compare between conditions and groups, controlling for mean days post-concussion. **Results:** There were no significant interactions for reaction time ($F_{2,52} = 2.51$; $p = 0.091$). We observed a significant task main effect ($F_{2,52} = 15.10$; $p < 0.001$). Unanticipated cut reaction times were significantly slower (0.552s) compared to anticipated cut (0.486s; 95%CI: -0.090, -0.042) and jump landing (0.518s; 95% CI: -0.058, -0.010). Jump landing reaction times were significantly slower than anticipated cut ($p = 0.031$; 95% CI: -0.056, -0.008). The control group anticipated cut reaction time cost (-10.7%) was significantly better than the concussed group (-0.8%; $F_{2, 25} = 5.26$; $p = 0.030$; 95% CI: -18.70, -1.01). No group differences were observed for unanticipated cut reaction time cost ($F_{2, 25} = 1.06$; $p = 0.313$). **Conclusions:** Previously concussed athletes are at higher risk for suffering musculoskeletal injuries after concussion. The mechanisms behind this increased risk are unknown. One plausible explanation is that previously concussed athletes experience deficits in neuromuscular control that adversely affect their movement and response to external stimuli. Functional reaction time is one aspect of this theory. Reaction time cost differences were noted between groups, suggesting previously concussed individuals may have lingering functional reaction time impairments even after complete return to participation. This preliminary investigation should be followed by more in-depth study of functional reaction time impairments acutely after concussion and throughout recovery.

The Relationship Between Sway Balance and Self-Reported Symptoms Following a Sports-Related Concussion

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Context: Balance™ System (SWAY) is an FDA-approved mobile application designed to objectively assess both balance and reaction time. It is marketed to athletic trainers as a sideline evaluation tool, but has not yet been assessed as to whether or not it has any clinical implication or relevance. **Objective:** To examine the relationship between balance and reaction time deficits as measured by an objective (SWAY) and subjective (PCSS) tool following an SRC. **Design:** This study was a prospective cohort study of pediatric patients that were treated for a SRC **Setting:** Clinical evaluation and data acquisition was performed at the Ben Hogan Sports Medicine Concussion Center from August 2015 - August 2016 **Patients or Other Participants:** Sixty-seven pediatric patients (n = 67; 15.5 ± 1.5 years; 37 males, 30 females) presenting within 14 days of injury (5.5 ± 2.9 days) volunteered for this study **Interventions:** All participants completed the PCSS and SWAY was used to measure balance and reaction time. The SWAY system calculates a score from 0 to 100 (0 = completely unstable, 100 = completely stable) for each of the following: combined, balance only, (feet) together, tandem (R), tandem (L), single leg (R), single leg (L), motion reaction time (MRT) score, and MRT (milliseconds). The symptoms *balance* and *feeling slowed down*, components of the PCSS, were used to determine

whether or not perception of symptoms associated with poor balance and decreased reaction time were related to an objective measure of either balance or reaction time **Main Outcome Measures:** Pearson product moment correlations were utilized to examine the relationship between SWAY scores and the PCSS *balance* and *feeling slowed down* scores **Results:** The self-reported *feeling slowed down* score was not related to any of the SWAY scores, but the self-reported *balance* score was positively correlated to single leg (R) score ($r = 0.246$; $p = 0.043$) **Conclusions:** These data suggest that subjective assessments of balance and reaction time are not related to SWAY scores. Further study is warranted using different objective measures of balance and reaction time to determine if patients suffering from an SRC are consistently inaccurate when perceiving such deficits. Additionally, baseline objective balance scores may be more useful than reliance on subjective measures of balance and reaction time as patients may not accurately discern whether or not balance or reaction time deficits are truly present.

Association Between Symptom Severity and Number of Symptoms Post-Injury and Symptom Resolution and Return to Participation Following Concussion

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Context: Recently, there has been increased consideration regarding the assessment and management of concussion. Despite these developments, the ability to predict time to symptom resolution (SR) and return to participation (RTP) are still clinical challenges. **Objective:** To determine if symptom severity and the number of symptoms reported within 48 hours post injury on the Sport Concussion Assessment Tool-3 (SCAT3) are associated with time to SR and RTP. **Design:** Prospective cohort. **Setting:** US Service Academies. **Patients or Other Participants:** 243 concussed cadets (168 males; 19.04 ± 1.35 y, 69.46 ± 4.06 in, 167.71 ± 33.67 lbs) at two US Service Academies enrolled in the Concussion Assessment, Research and Education Consortium. **Interventions:** Participant's concussion symptoms (range = 0-22) and symptom severity (range = 0-132) were documented at the time of initial injury (<6hrs) and 24-48hrs following injury, utilizing the SCAT3. Other data collected included sex, level of sport participation, time to SR and RTP. **Main Outcome Measures:** The primary outcome measures were days to SR and RTP following concussion. Univariate and multivariate regression models controlling for sex and level of sport participation were used to determine if SCAT3 scores, at the time of injury (<6hrs) and 24-48hrs following injury, were associated with time to SR and RTP. All data were analyzed using Stata SE version 10.0 and an alpha level of $p < 0.05$. **Results:** In univariate analyses, number of symptoms at the time of injury ($\beta = 0.80$, $p = 0.004$) and number of symptoms and symptom severity at 24-48hrs (Symptoms: $\beta = 0.93$, $p < 0.001$; Severity: $\beta = 0.27$, $p < 0.001$) were associated with time to SR (13.00 ± 14.87 days). On average, for each additional symptom reported at the time of injury and 24-48hrs post injury it took an extra day for symptoms to fully resolve. Number of symptoms and symptom severity at the time of injury (Symptoms: $\beta = 1.31$, $p < 0.001$; Severity: $\beta = 0.26$, $p = 0.002$) and 24-48hrs following injury (Symptoms: $\beta = 1.01$, $p < 0.001$; Severity: $\beta = 0.30$, $p < 0.001$) were associated with RTP time (25.05 ± 19.08 days). On average, for every 4 points higher on the symptom severity score at time of injury and 24-48hrs post injury, participants required an extra day for their symptoms to resolve. In univariate analyses, SCAT3 symptom and severity scores at both time points accounted for 2.7%-12.5% of the variability in time to SR and 7.1%-10.9% of the variability in time to RTP. Results were similar in multivariate models controlling for the influence of sex and level of sport participation; however, with these factors included in the model, SCAT3 symptom and severity scores accounted for 12.4%-16.3% of the variability in time to SR and 16.5%-24.2% of the variability in time to RTP. **Conclusions:** SCAT3 symptom and severity scores, at the time of injury and 24-48hrs following injury, are associated with time to SR and RTP following concussion and may have prognostic value in estimating these outcomes.

Influence of Self-Reported Learning Disabilities, Dyslexia, and Attention Deficit Hyperactivity Disorder on Symptom Presentation at Baseline and Post-Concussion

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Context: Recommendations regarding concussion management often indicate that medical history and co-morbid factors should be considered during evaluation and management. Learning disabilities (LD), dyslexia, and attention deficit hyperactivity disorder (ADHD) have been identified as potential modifying factors warranting further investigation as little is known about how these diagnoses affect patient presentation after concussion. **Objective:** To determine the influence of LD, ADHD, and dyslexia on symptom presentation at baseline and following concussion. **Design:** Prospective cohort. **Setting:** Secondary schools between the 2010-16 academic years. **Patients or Other Participants:** 4470 patients (3112 male and1358 female, age = 15.0 ± 1.1, grade = 9.1 ± 1.0) participating in interscholastic sports. **Interventions:** All participants completed the Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT) as part of a concussion baseline protocol and following concussion at the athletic trainer's discretion. Independent variables included self-reported diagnosis of LD, dyslexia, and ADHD (yes/no) as indicated on the demographic questionnaire administered within ImPACT. **Main Outcome Measures:** Dependent variables included the Total Symptom Score (TSS, the sum of 22 severity endorsements ranging from 0-6) and Total Symptoms Endorsed (TSE, the number of symptoms endorsed). Mann-Whitney tests were used to compare TSS and TSE across binary categories (yes, no) for LD, dyslexia, and ADHD at baseline and post-concussion. **Results:** Among 4470 respondents, 104 (2.3%) self-reported being diagnosed with LD, 84 (1.9%) with dyslexia, and 390 (8.7%) with ADHD. At baseline, individuals who self-reported a LD diagnosis scored higher ($p < .001$) on the TSS (11.4 ± 14.4) and TSE (4.8 ± 5.3) than those who reported no diagnosis [TSS (5.7 ± 9.5) and TSE (2.7 ± 3.7)]. Likewise, those who self-reported an ADHD diagnosis (TSS = 7.7 ± 11.2, TSE = 3.5 ± 4.2) scored higher ($p < .001$) than those who did not report this diagnosis (TSS = 5.6 ± 9.6, TSE = 2.7 ± 3.7). However, those self-reporting a diagnosis of dyslexia (TSS = 7.3 ± 9.4, TSE = 3.6 ± 4.5) did not differ from those not reporting dyslexia on either score ($p > .05$, TSS = 5.8 ± 9.7, TSE = 2.7 ± 3.7). At post-injury, the 104 participants with LD who were tested (TSS = 18.4 ± 20.3, TSE = 3.6 ± 4.5) scored higher ($p < .05$) than those without this diagnosis (TSS = 14.1 ± 18.2, TSE = 7.4 ± 6.4). The 66 participants who reported dyslexia (TSS = 16.7 ± 21.5, TSE = 6.8 ± 6.9) scored no differently ($p > .05$) than those who did not report this diagnosis (TSS = 13.8 ± 8.0, TSE = 5.8 ± 5.8) following concussion. The 347 tested who self-reported an ADHD diagnosis (TSS = 14.8 ± 17.7, TSE = 6.2 ± 6.0) scored no differently than those who did not report this diagnosis (TSS = 13.8 ± 18.1, TSE = 5.8 ± 5.8), both $p > .05$. **Conclusions:** This study reports mixed findings regarding the influence of LD, dyslexia, and ADHD on symptom presentation at baseline and following concussion. Patients with self-reported LD reported higher symptoms at baseline and following concussion. Those with ADHD reported higher symptoms at baseline, but not following concussion and those with dyslexia did not show differences in symptom presentation at either time point. While athletic trainers should be aware of patients with co-morbid factors, these findings suggest similar symptom presentations that may not warrant different management strategies.

Comparison of Concussion Symptoms and Injury-Related Characteristics in Student Athletes Based on Time to Report to Clinic

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Context: Following a mild traumatic brain injury (mTBI), student athletes vary in the time delay before they report to an outpatient sports medicine concussion clinic for a concussion evaluation. Little is known about whether specific injury characteristics or symptoms are related to an athlete's time to first clinic visit, and whether delays in clinic presentation are related to symptom recovery time. **Objective:** To determine differences in injury and symptom characteristics between student athletes who present to clinics either 0-6 days or 7+ days following mTBI. **Design:** Consecutive enrollment of clinical cohort using self-reported symptoms. **Setting:** Two outpatient sports medicine concussion clinics in the North Texas Concussion Network Prospective Registry (Con-Tex). **Patients or Other Participants:** 56 male and 75 female student athletes aged 10-19 who presented to the clinic 0-6 or 7-69 days after mTBI. **Interventions:** In person interview in the clinic setting using standardized Post Concussion Symptom Scale. Clinical history **Main Outcome Measures:** Concussion characteristics and symptom ratings. **Results:** The groups were similar in terms of frequency of loss of consciousness, needed Emergency Department visit, and concussion symptom log total scores, ($p > .05$). There was a significant difference in number of days until symptoms cleared between the student athletes who presented to clinic 0-6 days versus those who presented 7+ days (X =

5.21, p = .022), with the athletes who presented 7+ days having a longer time until symptoms cleared. **Conclusions:** Preliminary findings suggest an association between time to present to an outpatient sports medicine concussion clinic and time for concussion-related symptoms to resolve. Although additional analyses need to be conducted to rule out other confounding factors, these data provide support for athletic trainers to encourage athletes to be seen in a formal outpatient sports medicine concussion clinic in a timely basis to reduce symptom recovery time.

Clinical Postural Control Assessments and Health-Related Quality of Life in Individuals With a History of Concussion

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Context: Concussions are common injuries that result in health-related quality of life (HRQL), neurocognitive and postural control deficits. Recent investigations have determined that individuals with a history of concussion (HxC) are at an increased risk of sustaining lower extremity musculoskeletal injuries. It is unclear if individuals with a HxC exhibit performance deficits on the clinical postural control measures or patient-reported outcomes used to identify lower extremity injury risk. **Objective:** To determine if physically active adults with a HxC exhibit postural control or HRQL deficits compared to individuals with no history of concussion (NHxC). **Design:** Secondary data analysis. **Setting:** Laboratory. **Patients or Other Participants:** Fifty-one adults reported a HxC (age: 20.12 ± 1.38 years, height: 167.69 ± 11.41 cm, mass: 65.25 ± 14.09 kg) while 121 adults reported NHxC (age: 20.49 ± 2.57 years, height: 167.13 ± 14.77 cm, weight: 68.06 ± 15.84 kg) from a larger dataset. Participants included males and females from varsity and club sports, cheer and dance squads, university dance programs, and the physically active campus community. Participants were free from current injury or a history of lower extremity surgery. **Interventions:** Subjects completed an injury history form, the Disablement in the Physically Active Scale (DPA), and a series of clinical postural control assessments during a single session. The DPA is a 16-item, generic patient-reported outcome to examine current health status in physically active populations. Participants completed the modified Balance Error Scoring System (mBESS) and the anterior reach of the Y-Balance Test (YBT) barefoot on both limbs. The mBESS consisted of single-limb stance for 20s on firm and foam surfaces with eyes closed. Errors were recorded during one practice and test trial for each condition. Participants completed the YBT by maximally reaching anteriorly, maintaining single-limb stance, and returning to the starting position. Participants completed four practice trials followed by three test trials. Reach distances were normalized to leg length and averaged for analysis. **Main Outcome Measures:** The independent variable was group (HxC, NHxC) and the dependent variables were mBESS firm, mBESS foam, YBT, and DPA total. Average scores for the YBT, mBESS firm, and mBESS foam for each limb were pooled for analysis. Separate Mann-Whitney U tests examined group differences for each dependent variable. Alpha was set at $p \leq 0.05$ for all analyses. **Results:** There were no significant differences between groups for YBT (HxC: 62.20 ± 6.56%, NHxC: 61.07 ± 6.48%, Z = -1.43, p = 0.15), mBESS firm (HxC: 2.27 ± 1.85, NHxC: 2.63 ± 1.90, Z = 1.21, p = 0.23), mBESS foam (HxC: 6.80 ± 1.98, NHxC: 6.80 ± 1.77, Z = -0.086, p = 0.93), and DPA total scores (HxC: 9.71 ± 10.57, NHxC: 8.05 ± 9.29, Z = -1.15, p = 0.15). **Conclusions:** Based on this retrospective study, individuals with a HxC did not exhibit deficits on the YBT, mBESS firm, mBESS foam, or the DPA total compared to individuals with NHxC. Future research should investigate these variables prospectively when examining return to activity following concussion and subsequent risk of lower extremity injury.

A Single Bout of Cryotherapy Does Not Alter the Transcriptome or Metabolome of Human Skeletal Muscle

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Context: Cryotherapy is a commonly used therapeutic modality for skeletal muscle injuries in sports medicine. Despite the widespread use of this modality, there is little known about the biochemical effects of cryotherapy in human skeletal muscle tissue. **Objective:** To determine the effects cryotherapy has on the transcriptome and metabolome of skeletal muscle. **Design:** Paired design human study **Setting:** Controlled research laboratory. **Patients or Other Participants:** Eight healthy male subjects (24.7 ± 4.5 years, BMI 22.2 ± 1.6). **Interventions:** Each subject received ice-cup massage or sham cup massage over a 45 cm^2 area on each thigh for 15 min. Two hours after application, bilateral biopsies were taken at a depth of 2 cm from the vastus lateralis in the center of the ice or sham area. **Main Outcome Measures:** Muscle biopsies from each leg were then subjected to microarray or LCMS-based metabolomics analysis. Differences between groups were tested using paired t-tests ($\alpha = 0.05$). Intramuscular (IM) temperature 2 cm deep to the subcutaneous layer was predicted from regression equations of skin temperature. **Results:** At the end of the 15 min application, IM temperature was reduced by 9.8 ± 1.6°C ($P < 0.001$), and by two hours remained 3.3 ± 1.1°C ($P < 0.001$) cooler than prior to administration of cryotherapy. Microarray analysis revealed changes in some non-coding RNAs, but no differences were found for protein coding genes. Further analysis by qPCR showed no significant differences in so-called "cold-shock" genes which have been reported to be induced in animal tissue exposed to substantial cooling. Metabolomics analysis of over 60 metabolites involved in glycolysis, oxidative phosphorylation, and amino acid metabolism showed significant decreases in the hexose sugars by 0.2821 abundance RU ($P = 0.02$) and hypoxanthine by 0.2741 abundance RU ($P = 0.04$) in cooled skeletal muscle tissue. **Conclusions:** A clinically relevant administration of cryotherapy does not seem to have a significant impact on the transcriptome nor metabolome of otherwise healthy skeletal muscle 2 hours after administration.

Effect of Cold Water Immersion on Metabolic Rate in Humans

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Context: Cold water immersion is a widely used form of cryotherapy in the active populated despite the limited knowledge on its physiological effects. From an injury standpoint, reducing metabolic rate is advantageous to prevent secondary injury. In contrast increased metabolism can be beneficial in ridding the body of unwanted metabolites. **Objective:** This study looked to determine the effect of cold water immersion on metabolic rate. Understanding this phenomenon will help determine appropriate clinical applications of cold water immersion and lead to a better understanding of cryotherapy in general. it was hypothesized that 15 minutes of cold water immersion at 9° C would result in increased metabolic rate compared to ambient conditions. **Design:** This study design was a crossover trial. **Setting:** This study was conducted in an Athletic Training Center at a University. **Patients or Other Participants:** Participants were volunteers consisting of 6 males and 4 females with no current injury or illness, taken from the student population of the University of Wisconsin-La Crosse (mean ± SD, age: 20.8 ± 1.5 yr, height: 1.76 m ± .09 m, mass: 75.2 ± 13.8 kg, Calculated BMI: 24.2 ± 3.4 kg/m^2). **Interventions:** Participants completed a 15-minute treatment of waist deep cold water (9° C) immersion. Metabolic rate measurements were taken via indirect calorimetry using a Jaeger Oxycon Mobile Unit for 5 minutes prior to treatment, 15 minutes of treatment, and 5 minutes' post treatment for a total of 25 minutes. The 5 minute pre-treatment interval was used as a baseline. Statistical analysis was completed using a one way repeated measures ANOVA test to compare treatment intervals to baseline intervals. Prior research used similar methods of data collection via spirometry and indirect calorimetry. **Main Outcome Measures:** The main

outcome measeures were metabolic rate measurements at 5 minute intervals. **Results:** Cold water immersion resulted in elevated metabolic rates for 8 of 10 participants during the first 5 minutes of treatment and for 6 of 10 in the 5 minute post treatment ($p < 0.05$). A second statistical analysis excluding the first 30 second data point in the 5-10 and 20-25 minute treatments was used to account for movement in and out of the whirlpool. The second analysis showed the same results as the first with the exception of one participant who no longer displayed a statistically significant change in the 20-25 minute interval. **Conclusions:** Based on the findings here, clinical applications of cold water immersion for 15 minutes at 9° C resulted in an increase in metabolism, possibly as a coping mechanism to a changing environment. Cold water immersion, therefore, should not be indicated as a treatment for acute injury but instead may have a role in chronic injury and exercise recovery as is already observed clinically.

A Comparison of Cryotherapy and Heat Therapy and Their Effect on Muscle Recovery Following Exercise

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Context: Optimizing recovery during training is beneficial for performing successive bouts of training or competition over a season without associated fatigue or overtraining. The inability to repeat high level of performance in the days following intense training is frequently attributed to peripheral fatigue involving metabolite accumulation and muscle damage. Thus, various techniques have been suggested to accelerate the clearance of muscular damage or metabolite accumulations and optimize recovery. Cold water immersion (CWI) and warm water immersion (WWI) are two modalities commonly used to enhance recovery. However, at this time their efficacy is not fully understood and comparisons between the two have not been investigated. **Objective:** To examine and compare the effects of CWI and WWI on recovery following a single bout of intense exercise. **Design:** A randomized and counterbalanced single-blind cross-over design. **Setting:** Athletic training facility. **Patients or Other Participants:** Twelve healthy recreationally active males and females (age = 19.6 ± 1.4 years, height = 171.9 ± 13.2 cm, mass = 72.5 ± 3.1 kg) who did not suffer from any contraindication to CWI or WWI. **Interventions:** Each participant reported to the facility for three sessions separated by a period of at least one week. At each session, the participants completed a drop jump protocol consisting of 100 drop jumps (5 sets of 20) while wearing a weighted vest equivalent to 10% of the body mass. The participants dropped off a 0.61-m platform with both legs and performed a maximal vertical jump in place immediately upon landing. A 10-s rest was provided between jumps and a 2-min rest between sets. Immediately following exercise, the participants completed one of three treatment conditions, CWI, WWI or control. The CWI and WWI conditions consisted of immersion in 10°C and 43°C water respectively to the level of the iliac crests for 20-min. The control condition consisted of seated recovery with no modality for 20-min. **Main Outcome Measures:** General muscle soreness using a visual analogue scale (VAS), maximum vertical jump height ($Vert_{max}$) and Yo-Yo intermittent recovery test (Yo-Yo IR1) performance were assessed immediately prior to and 24-h following the bout of exercise. **Results:** The two-factor mixed analysis of variance (ANOVA) revealed a significant Test main effect ($F_{1,12} = 36.91$, $p = .001$) for VAS, as the rating was greater at posttest (18.97 ± 18.67 mm) as compared to pretest (1.31 ± 2.26 mm). The treatment had no effect however, as a significant Condition x Test interaction ($F_{2,24} = .758$, $p = .479$), was not observed. Likewise, the treatment had no effect on $Vert_{max}$ and Yo-Yo IR1, as a significant Condition x Test interactions were not observed ($F_{2,24} = .587$, $p = .564$ and $F_{2,24} = .318$, $p = .731$). **Conclusions:** Neither CWI or WWI improved recovery 24-h following a single bout of the drop jump protocol. Future studies might investigate a more intense and sport specific bout of exertion requiring recovery and assess the effectiveness of these treatments on them.

Effect of Cold Water Immersion or Contrast Water Therapy on Muscle Soreness After Exercise

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Context: Tissue damage leads to delayed onset muscle soreness (DOMS), often resulting in pain or discomfort that gradually increases within the first 24 hours post-exercise, and typically peaks at 48 hours post-activity. Cold-water immersion (CWI) and contrast water therapy (CWT) are commonly used as interventions for reducing DOMS; however, it remains unclear which treatment is more beneficial. **Objective:** To determine if post-exercise cold-water immersion decreases muscle soreness compared to contrast water therapy at 48 hours post DOMS inducing exercise. **Design:** Controlled laboratory study. **Setting:** Laboratory. **Patients or Other Participants:** Thirty-nine healthy college student volunteers participated in the study (20 males, 19 females; age = 20.36 ± 1.35; height = 174.93 ± 8.57 cm; weight = 76.30 ± 13.67 kg). **Interventions:** Subjects performed 5 sets of 20 drop jumps from a 0.6m box to induce DOMS, with 10 seconds of rest between jumps and 2 minutes of rest between sets. Subjects were randomly assigned to a CWI (10^0 C) or CWT (1:1 ratio of 40^0 C and 10^0 C) intervention up to the iliac crest for 10 minutes immediately, 24, 48, and 72 hours post-exercise. **Main Outcome Measures:** Subjects identified perceived muscle soreness on a 11-point (0 = no pain; 10 = most intense pain imaginable) numeric pain rating scale (NPRS) measured at baseline, immediately post exercise, and at 24, 48, 72, and 96 hours post exercise. An independent-samples *t*-test was used to compare muscle soreness between groups at 48 hours with an alpha level of 0.05 for statistical significance. Effect size was calculated. **Results:** There was a statistically significant difference in NPRS scores for the CWI ($M = 2.90$, $SD = 1.92$) and CWT ($M = 4.32$, $SD = 2.41$); $t(37) = 2.04$, $p = 0.049$, interventions at 48 hours. Further, Cohen's effect size value was $d = -0.66$. **Conclusions:** CWI significantly decreased muscle soreness compared to CWT 48 hours post DOMS inducing exercise. Additionally, the effect size indicates the intervention had a moderate effect at 48 hours. These results add to previous literature indicating CWI is more effective than CWT to treat muscle soreness associated with DOMS. CWI can be considered superior to CWT to decrease muscle soreness associated with DOMS at 48 hours post-exercise and should be considered as an intervention in a plan of care to treat DOMS.

Testicular Torsion in a Collegiate Male Soccer Player

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Background: A 20 year-old African American male collegiate soccer player (height: 165 cm and weight: 143 lbs) presented to the athletic training facility with complaints of right scrotal and testicular swelling and pain. His decision to seek treatment was prompted by a less than 36-hour history of right scrotal and testicular pain and swelling developing the morning after a low intensity evening practice with no trauma. Upon further evaluation the patient describes pain in right testicle with radiation to right inguinal ligament and right oblique muscles. Additional associated symptoms consist of nausea, vomiting, and altered gait mechanics. The patient denies fever, denies dysuria, and denies penile discharge. Exacerbating factors consist of movement and not urination. The patient denies engaging in sexual activities within 48 hours. The patient indicated a previous history of right testicular swelling after prolonged strenuous activity requiring no intervention and occurring approximately 12 years prior. **Differential Diagnosis:** Testicular torsion, epididymitis, hydrocele, epididymo-orchitis, torsion of the spermatic cord. **Treatment:** The patient was examined by a physician 30 minutes after initial evaluation completed by university athletic trainers. Initial physician's examination included right testicular pain and swelling. The right testicle was described as enlarged, tender, 6 centimeters in length, firm, appearing higher in scrotum and with abnormal position. Real-time gray scale sonography and Doppler ultrasonography was used to evaluate the scrotal contents. Results showed findings compatible with testicular torsion with likely testicular infarction. A testicular torsion repair (orchiopexy) was performed by the emergency department (ED) on-call Urologist six hours after the initial athletic trainers' evaluation. The patient was admitted overnight for pain management reasons. Three days post-operation the patient developed a high grade fever. The urologist prescribed an antibiotic for possible infection. Four days post-operation the patient was admitted to the ED for continued pyrexia. The patient was seen by the urologist five days post-operation and a second ultrasound was ordered. Results from the Doppler ultrasonography included complete testicular infarction. An orchiectomy (testicular removal) was performed that night to remove the necrotic testicle. The evening of the sixth day post-initial operation the patient was discharged from the hospital in the evening. Two days later the patient was seen by the urologist to remove the drain placed during surgery. Nine days post-initial operation the patient was seen by the team physician who conducted the initial evaluation. The patient was instructed to ease into activity after suture removal and cessation of pain. Sutures were removed 12 days post-initial operation by the urologist. The patient completed 15 days of functional rehabilitation after suture removal to gain comfort with athletic movements in a controlled environment. The patient was cleared for participation with no restrictions 28 days post-initial operation. **Uniqueness:** Research indicates the critical time for testicular salvage following torsion has been reported at approximately 6 hours. A history longer than 10 hours is a specific sign of testicular non-viability and most often requires orchiectomy. Research has determined after six hours less than 10 percent of patients experience testicular salvage. Orchiopexy was performed despite findings of likely testicular infarction. Onset of symptoms occurred spontaneously the morning after light soccer activity. The patient required both an orchiopexy and orchiectomy. Rehabilitation was performed for patient comfort. **Conclusions:** This case highlights testicular torsion in a collegiate soccer player requiring multiple surgical interventions. Cases of scrotal and testicular discomfort and swelling required prompt and immediate care. Additionally, athletic trainers and physicians should emphasize the importance of orchiectomy after 24 hours of testicular infarction.

Acute Left Cerebrovascular Accident in Division I Collegiate Football Player: A Case Report

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Background: A 19-year old African American male NCAA Division I football player was on his way to morning football strength/conditioning training and noticed a sudden onset of right face, arm and leg paralysis with aphasia. A friend, who was staying with him, noticed the abnormality and called emergency medical personnel. A teammate notified the Athletic Trainer, who immediately met the patient at the hospital. Patient was diagnosed with an acute left cerebrovascular accident (CVA). Upon hospitalization, he was administered tissue plasminogen activator (tPA) based on presenting signs and symptoms. Upon post tPA re-evaluation, the patient had a reduction of severity in symptoms originally experienced, but was administered another dose of tPA as was protocol. Through imaging it was discovered that the athlete had a previously unidentified patent foramen ovale (PFO), between the left and right atrium that had not closed after birth. **Differential Diagnosis:** Seizure, migraine aura, and syncope. **Treatment:** Physicians confirmed the diagnosis of a CVA via signs/symptoms, Echocardiogram (ECHO), Transesophangeal Echocardiogram (TEE), Computerized tomography scan (CT), CT Angiogram, X-Ray and Magnetic Resonance Imaging (MRI). In addition to CVA, the patient had a PFO that did not close post birth. Upon discharge, the cardiologist expressed that the patient would possibly no longer be able to participate in contact-sports, but stated the importance of maintaining a healthy life-style. Patient was recommended daily anti-platelet therapy with aspirin post hospital stay and to follow-up with cardiologist regarding PFO. A month and a half after patient's CVA episode, the patient had PFO closure surgery and was prescribed Plavix and Aspirin for

an anti-platelet regimen. Based on the 3 month post-surgical ECHO TEE bubble study, the patient was scheduled for 3 month follow-up. The patient was released to start light physical activity three times a week. At the patient's 5 month post-procedure follow-up, an ECHO TEE bubble study distinguished minimal intracardiac shunting, but had 75-85% PFO closure from tissue generation. Patient continues with moderate physical activity and anti-platelet therapy until 8 month follow-up. At patient's 8 month follow-up, the ECHO TEE bubble study showed minimal right-to-left shunting, but had 90-95% closure upon tissue generation. The cardiologist discontinued Plavix from his anti-platelet regimen and directed patient to continue with same exercise regimen until 10 month follow-up. At patient's 10 month follow-up, ECHO TEE with bubble study determined trivial right-to-left shunting with 98% PFO closure. Four bubbles escaped the closure every five heartbeats. Patient is able to increase cardiovascular activity level and incorporate light to moderate strength training. The patient is scheduled to have a 15 month follow up in hope of complete PFO closure. **Uniqueness:** The uniqueness of this case is due to the age and lack of history of this physically active 19 year old patient who suffered from a CVA. Secondary to the PFO, the patient had minimal risk factors that occurred. Risk factors that are commonly found in those who suffer from a stroke include: age, gender, high blood pressure, family history, blood clots, heart disease, high cholesterol, diabetes and sickle cell anemia. It was discovered that his biological father had a history of blood clots that may be a predisposing factor for the patient's CVA. Stroke patients who are younger than 55 are six times more likely to have a PFO than patients with an idiopathy. **Conclusions:** The ability to quickly identify the signs and symptoms of a stroke in patients of all ages is important for a satisfactory prognosis. Although strokes are less common in those who are young and physically active, the underlying cause can be due to a secondary concern, in this case an unknown open PFO.

Surgical Treatment of Wolff-Parkinson-White Syndrome in a Collegiate Track Athlete

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Background: A 20-year-old female National Collegiate Athletic Association Division I track athlete presented for her pre-participation physical evaluation before intercollegiate athletic activities. The athlete reported 2 to 3 minute episodes of chest discomforts associated with palpitations during long runs and weight training about every month for the past 5 years. The athlete denied any associated dizziness, lightheadedness, presyncope, or syncope. An episode has never occurred during a competition. The athlete was previously diagnosed with Factor V Leiden mutation, but has never had a blood clot or previous surgery. **Differential Diagnosis:** Atrial Fibrillation, Atrial Tachycardia, Ebstein Anomaly, Lown-Ganong-Levine Syndrome, Hypertrophic Cardiomyopathy, Mahaim-Type Pre-excitation. **Treatment:** The athlete was referred to a physician with specialties in cardiac electrophysiology and cardiology. The physical exam did not present any abnormalities. An electrocardiogram (EKG) was performed, where the athlete presented with normal sinus rhythm with short PR-interval of 110 ms, QRS of 126 ms, and QTc of 464 ms. Due to this pattern on the EKG, the physician diagnosed the athlete with Wolff-Parkinson-White (WPW) Syndrome. A transthoracic echocardiogram was performed, where no significant abnormalities were found, with normal valvular structure and function. An exercise stress echocardiogram (ECG) was indicated due to an abnormal electrocardiogram, the exercise stress ECG findings were not suggestive of ischemia, delta waves disappeared with exercise and returned in recovery, and no exercise-induced arrhythmias were found. The athlete and her family decided to continue with a cardiac ablation procedure rather than antiarrhythmic drug therapy considering the high cure rate and fewer long-term side effects. In addition, the NCAA would restrict the antiarrhythmic drug as it is considered a performance-enhancing drug. A Cardiac MRI of the left atrium and pulmonary vein anatomy was indicated for pre-ablation mapping. An electrophysiology study and ablation surgical procedure was performed for supraventricular tachycardia with a right inferolateral accessory pathway. Activation mapping of the heart was performed for the earliest electrical potential of the Bundle of Kent during atrial pacing, which was localized to the inferolateral tricuspid annulus and the ablation was performed at the site resulting in a successful ablation of the right inferolateral accessory pathway. The athlete wore an event heart monitor for 28 days, and did not have any symptoms during this time period. The athlete was allowed to progressively return to exercise during this time after a week of bed rest. Due to her Factor V Leiden mutation, she was given 1 month of anticoagulation medication. Twenty-nine days after surgery the athlete experienced chest discomfort with a rapid increase in heart rate during track practice. The athlete has opted for a second ablation procedure which is yet to be scheduled. **Uniqueness:** The prevalence of WPW is 1-4.5 in 1000 children and adults. This is a unique case due to the athlete's participation in the National Collegiate Athletic Association Division I for two years at a different institution prior to referral for testing and diagnosis at the present institution. It is also a unique that the first ablation proved unsuccessful, a second surgical procedure to ablate the non-suspected accessory pathway was deemed necessary. **Conclusions:** This case of WPW in a collegiate track athlete was treated by surgical ablation of the accessory pathway. Due to recurrence of symptoms, a second surgical ablation of an accessory pathway is necessary for continued sport participation in order to reduce the athlete's' risk of sudden cardiac death. It is essential that pre-participation physicals are performed every year before athletic participation to detect abnormalities such as WPW that can lead to sudden death in sport.

Bilateral Pulmonary Emboli in a Collegiate Softball Player: A Case Report

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Background: Pulmonary embolism is a rare condition in young, healthy athletic populations. A 20 year old, Division I softball student-athlete self-reported iron deficiency anemia but failed to disclose family history of pulmonary emboli or the recent addition of oral contraceptive to her daily health routine. The athlete complained of decreased exercise tolerance throughout the season. She acutely presented with deep chest pain, cough, shortness of breath, and wheezing during short bouts of exercise. These symptoms were exacerbated during a particular practice while base running but resolved when at rest. After consultation with the athlete's athletic trainer, it was decided that she would see the team physician the next day if symptoms were still present. Throughout that night, shortness of breath, wheezing worsened and the chest pain increased intensely resulting in immediate referral to the emergency department. **Differential Diagnosis:** Respiratory infection, allergy induced bronchospasm, pneumonia, intercostal muscle strain, spontaneous pneumothorax. **Treatment:** After a review of lung x-rays and blood tests, the student-athlete was diagnosed with acute bilateral pulmonary emboli. The iron deficient anemia was confirmed, likely caused due to the blood clots. Immediately following diagnosis, anticoagulants (in pill form) were administered to counteract the clots. She was prescribed Lovenox (15 mg) twice daily for 21 days (intramuscular injection), followed by Rivaroxaban 20 mg one time a day for 6 months. She immediately discontinued the use of estrogen oral contraceptives. In addition to medication, she received three iron infusions (iron dextran .9% 600mL/diphenhydramine 25mg) intravenously for treatment of iron deficient anemia over three separate weeks. She was medically disqualified from organized sporting events, but was allowed to travel with the team to NCAA competitions, which included flying. After flying for approximately five hours, the athlete complained of worsening pain and wheezing, thus was admitted to the emergency department upon arrival to the destination. Bilateral pulmonary emboli were confirmed and medication for pain was administered. She was cleared to fly home after this incident. **Uniqueness:** Documented cases of student-athletes with genetic risk factors such as the Factor V Leiden and D-Dimer tests for the diagnosis of pulmonary embolism are rare. There is a limited number of documented cases of bilateral pulmonary emboli in female collegiate athletes. The athlete was allowed to partake in air travel trips with no documented restrictions within days of being diagnosed with bilateral pulmonary emboli. After the first flight, the athlete's symptoms worsened causing emergency room admittance, but she was again allowed to fly to return home following the emergency rooms confirmation of pulmonary emboli. **Conclusions:** Due to the rare incidence of pulmonary embolism occurring in the young athletic population, it is important for athletic trainers to be aware of the signs and symptoms of pulmonary emboli. Self-reported answers to history questions during the pre-participation exam should be discussed with the athlete's health care team. It is also important to have a complete medication list on file regardless of whether the prescribing physician is affiliated with the athletics program. Athletes who have a family history of pulmonary embolism or blood clotting disorders may need to undergo more rigorous pre-participation laboratory or diagnostic testing prior to performing their athletic event at the collegiate level. This includes potential blood tests for specific factors, as well as closer monitoring of medications that have been prescribed. Athletes should be encouraged to share any changes in their training performance or medical status (including medications) with their athletic trainers in order to potentially prevent a fatal event due to pulmonary embolism. Team decision makers should be aware of potential risks for athletes who may have to travel with a diagnosed blood clotting disorder.

Multiple Kidney Lacerations in a Male Collegiate Football Player

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Background: An 18-year-old male freshman collegiate football player (198 cm; 114kg) was participating in NCAA sanctioned game during the third week of the season, when he received a blow to the left posterolateral side of his trunk. The patient reported the absence of an audible or perceptible "crack" or "pop". He reported immediate pain in the left posterolateral lumbus region of his trunk as well as a feeling of nausea and light-headedness. The patient had no past pertinent history of back or abdominal injuries but had been involved in a moped accident three days prior which left him minor abrasions of the arms and knees. He had no obvious deformities or swelling, but did report tenderness to the aforementioned region of pain. **Differential Diagnosis:** Latissimus dorsi/oblique contusion, rib fracture, renal injury. **Treatment:** Patient was given ice and NSAIDs to relieve the pain and completed light stationary biking in an attempt to progress to return to play. Following 15 min of treatment without a relief of symptoms patient was moved inside the facility for X-Rays. The X-Rays were negative, but as symptoms did not improve the patient was held for the remainder of the competition. After the competition event was complete, the patient presented with hematuria and was transported to the emergency room where he was held overnight and, following CT scans, was diagnosed with three lacerations of his left kidney. The patient was informed that surgery was not recommended but removal from activity for six to eight weeks was necessary for proper healing. He was prescribed oral analgesics and bed rest and followed up with the team physicians. The patient remained on pain medication for five days and also began a regiment of Mirilax following an episode of constipation. At six days' post-injury, he

returned to tutor appointments only due to some discomfort in ADLs. At nine days post injury, patients discomfort level had decreased with ADL's and he returned to all classes and tutor appointments. At 11 days post injury the patient stated absence of hematuria, however he continued to follow up with team physicians twice a week. At 5.5 weeks post injury patient followed up with a urologist. A renal ultrasound confirmed signs of normal healing tissue and patient was cleared to resume conditioning. The patient is currently completing stationary bike/elliptical conditioning for two weeks with plans to progress to running (at eight weeks post injury) and progress to weight room activity (at nine weeks post injury). **Uniqueness:** While a blow to the posterior trunk is the most common mechanism of injury, the occurrence of kidney injuries in football is extremely rare. In a retrospective review of NFL injuries over a 19-year period (1986-2004) the incidence of renal injury was .000012 per an exposure resulting in 52 cases. When looking specifically at kidney lacerations there were only six incidences over the 19-year period. **Conclusions:** Although the incidence of kidney lacerations in football is rare, it is an important differential diagnosis to include during an evaluation of lower back pain following a direct blow to the low back. When evaluating these injuries there is a need for attention to the differentiating signs and symptoms, most noticeably hematuria, in order to distinguish between potential diagnoses.

Cystic Gastrointestinal Stromal Tumor in a Collegiate Athlete

Heller AJ, Thompson C, Grugan C: Rowan University, Glassboro, NJ

Background: A 21 year-old African American male division III football player with past history of Wolf-Parkinson-White syndrome and chronic dyspepsia reported to the athletic training facility complaining of abdominal pain. The patient had no recollection of trauma to the area but did claim to suffer from indigestion. Examination revealed the patient had a distended stomach over the upper left quadrant. A nontender malignancy could be palpated in the area. The patient was referred to the team physician. **Differential Diagnosis:** Tumor, Mononucleosis, Abdominal Cramp. **Treatment:** The patient was sent for an x-ray of the chest and abdomen, revealing non-specific opacification under the left hemidiaphragm replacing the gastric air bubble and displacing the transverse colon inferiorly. A CT scan was then ordered, revealing an 18 centimeter multiloculated cystic mass in the upper left quadrant displacing the stomach, pancreas, transverse colon, and left kidney. The patient was referred to an oncologist, who drained and biopsied the mass. The patient presented at the emergency room several days later after becoming septic; here, surgeons decided to prematurely remove the cyst which included the spleen, portions of the stomach and a group of lymph nodes. Following surgery the patient sustained a pneumothorax, which was treated during his 12 day stay at the hospital. At this point, biopsy revealed the mass was a gastrointestinal stromal tumor(GIST). After removal of the tumor, it was decided the best treatment was for the patient to receive a body scan every 6 months and will continue to do so for 3 years. **Uniqueness:** The median age of those diagnosed with GIST is 66-69 and only 3 percent prevalence under the age of 21. GIST is one of the most common types of sarcoma, however; sarcoma-type cancer only occurs in 1 percent of all cancer patients. The median tumor size is between 5 and 8 centimeters. Our patient presented well below the median age for an already rare cancer with and with a tumor 3x the size of median. **Conclusions:** Following presenting to Rowan University athletic training staff with abdominal pain, the patient was referred and eventually diagnosed with a gastrointestinal stromal tumor(GIST). Following drainage and infection, the tumor was removed and the patient has periodically received body scans. This is an incredibly rare cancer to begin with, and even more rare for the patient's age.

Splenic Rupture in Division III Football Player With Undiagnosed Mononucleosis

Pelton MR, Gay JL, Heebner NR: Centre College, Danville, KY; University of Kentucky, Lexington, KY

Background: A 19-year-old male Division III collegiate football player landed on his left arm after diving for a pass during a one on one practice drill. A defender landed on top of the athlete driving his left arm into his side. The athlete returned to play after catching his breath but removed himself after several plays. He reported to the head athletic trainer (ATC) that he felt a stabbing pain in his left mid flank region and was tender to palpation over his left rib cage and sternum. The athlete iced for 15 minutes and, after no relief, was sent inside to the athletic training room with an athletic training student to monitor him. The athlete was positioned in a supine hook lying position for comfort. After practice, the head ATC took the athlete's vitals, which were normal. The athlete tried to sit up but with every attempt would become pale, uncomfortable, and nauseous. After several unsuccessful attempts to sit up, the head athletic trainer decided the athlete needed further examination by physicians due to the abnormal circumstances. The ATC called emergency medical services (EMS), and the athlete was transported to the local hospital. **Differential Diagnosis:** Rib contusion, rib fracture, pneumothorax, ruptured spleen. **Treatment:** Diagnostic ultrasound testing in the emergency room revealed a ruptured spleen. Blood work revealed the athlete was positive for the Epstein Barr virus which causes mononucleosis. The athlete's vitals continued to stay normal throughout the stay in the emergency room. A general surgeon was consulted, and a CT scan was conducted revealing a grade 3 rupture of the spleen, which warranted surgery. The athlete was transported to a larger hospital and underwent an interventional radiology procedure with the use of a coil to control the bleeding. **Uniqueness:** The athlete's condition was unique because his vitals remained stable throughout the management of the case, from initial injury to arriving at the second hospital. Also, the athlete had not been diagnosed or showed symptoms of mononucleosis prior to the injury (common signs and symptoms of mononucleosis include: fever, sore throat, adenopathy and malaise). According to current literature, only 9% of all subjects with splenic ruptures presented with no symptoms of mononucleosis, suggesting this instance rare. Additionally, there are a limited number of cases in athletic populations that were treated with intervention radiology, most cases were resolved through splenectomy. Interventional radiology is unique because it is non-invasive and clots the blood source through the use of catheters and coils. There are also limited return to play protocols in the literature for this type of procedure in college football athletes, which makes the ATC's role in returning the athlete complex and warrants continuous communication and collaboration with team physicians **Conclusions:** The athlete has safely returned to light aerobic activity since the initial injury in September 2016. He will not return for the remainder of football season but will most likely be cleared before the season next fall. It is important for athletic trainers to be aware of emergent injuries since a splenic rupture can result in death if not cared for immediately. In addition, ATCs need to be aware that some predisposing factors for internal illnesses do not always present with significant signs and symptoms, and in some rare cases, can go unreported. It is important for the ATC to be aware of this new treatment as outcomes and specific rehabilitation and return to play criteria are not published yet.

Primary Cortisol Resistance in a Division III Female Basketball Athlete

Overhiser AL, Fischer TY, Heebner NR: University of Kentucky, Lexington, KY; Centre College, Danville, KY

Background: A twenty-year old female collegiate basketball athlete began experiencing episodes of fainting during her freshman year of high school when she was initially diagnosed with anxiety and vasovagal syncope. This athlete continued to participate during her high school career when her episodes of fainting became more prolonged and occurred more often. After seeing an endocrinologist and completing a baseline adrenocorticotropic hormone (ACTH) test. This athlete was diagnosed with Primary Cortisol Resistance (PCR). Primary Cortisol Resistance is defined as increased plasma cortisol concentration and high urinary free cortisol, resistance to adrenal suppression by dexamethasone, and the absence of clinical stigmata of Cushing syndrome. The athlete has been able to manage her PCR episodes, however symptoms and fainting still persist. The athlete is currently beginning her junior year of college basketball and the fainting episodes have begun to include convulsions, not usually seen with PCR. **Differential Diagnosis:** Primary cortisol resistance, vasovagal syncope, hyperthyroidism, epilepsy, narcolepsy, and convulsive syncope. **Treatment:** Athlete is continuing to see her Endocrinologist but has also scheduled appointments s with a Neurologist, as well as a sleep specialist. The athlete has had a multitude of pharmacological interventions, however, none have been successful at completely resolving signs and symptoms. Despite the fainting related to PCR the athlete continues to participate in Basketball, which requires a unique management and treatment by the athletic trainers both on and off the court. For the last few years the athlete has used beverages, such as carbonated soft drinks, to avoid fainting spells. The athlete has become familiar with symptoms that let her know she is

likely to have an episode [NH1] and notifies the coaching and athletic staff as well as pull herself from participation. **Uniqueness:** A review of literature shows Very little previous studies regarding the measured prevalence of PCR, although it is known to be rare. While patients with PCR typically present with hypertension and obesity, this particular athlete has neither of these characteristics; this athlete is approximately 5'9 and one-hundred and twenty-eight pounds. Additionally, despite very limited research, the athletic trainers have been able to work with the athlete to try to minimize fainting spells and allow her to continue to participate in sport despite a complete diagnosis. **Conclusions:** There is yet to be a conclusion as the athlete is waiting to be seen by her endocrinologist and sleep specialist. Athlete is still participating in activity but with limited repetitions and non-contact activity during practice. More recently the athlete had multiple episodes in short time frame, at that time athlete was not participating in practice and limited to the use of a upper body ergometer and was not required to attend morning practices during their two-a-day practice schedules. An important take away is that cases that are not easily diagnosed and treated such as this case, require a team approach in avoiding and managing episodes when they arise. Athletic trainers must work with physicians to determine the most appropriate means of activity modification and symptom management if the athlete is going to continue to participate in sports or if continued participation is appropriate. It is important that the Athletic trainer have the athlete make sure the coaching staff, teammates, friends, and college professors are well aware of the athlete's condition and seriousness as to not activate EMS unnecessarily. Athletic trainers can hold an important role when trying to manage PCR, helping to inform individuals involved as well as helping the athlete to manage symptoms and maintain a level of activity.

Management of a Collegiate Softball Player With Congenital Adrenal Hyperplasia: A Case Study

Cage SA, Foster AL, Herb CC, Ranucci AC, Warner BJ: University of Texas, Tyler, TX; Weber State University, Ogden, UT; ‡Los Angeles Dodgers Organization, Los Angeles, CA; Grand Canyon University, Phoenix, AZ

Background: An 18-year-old female collegiate softball player reported to the athletic training staff during pre-participation physicals with Congenital Adrenal Hyperplasia (CAH). Typically with CAH, the adrenal glands fail to produce the necessary amounts of cortisol in the body. This deficit can cause multiple developmental problems as well as patients suffering from an adrenal crisis. The condition had been successfully managed since birth, with only occasional incident. The condition was well managed with a regimen of 0.1 mg Florinef once daily by mouth and 10 mg Hydrocortisone (Cortef) three times daily by mouth. In the event of an emergency, the athlete had an injectable kit with 100 mg Solu-Cortef for intramuscular injection. Prior to the athlete initiating participation in team activities, the student-athlete was involved in a meeting with her mother, head softball coach, head athletic trainer, and assistant athletic trainer to discuss management guidelines throughout the season. Solu-Cortef kits were dispensed to the certified athletic trainer for softball, the softball coaching staff, the strength and conditioning coach, and the student-athlete herself. A plan of care was implemented that, should the student-athlete suffer from injury or illness, she would receive a Solu-Cortef injection and be transported immediately to the local emergency department. **Differential Diagnosis:** CAH confirmed by neonatal testing. **Treatment:** All sports medicine professionals and coaching staff that would come in contact with the student-athlete were educated on proper protocol if the student-athlete suffered an injury. This protocol was formulated in collaboration between the athlete's endocrinologist, the team physician, and the sports medicine professionals. The student-athlete completed the non-traditional fall softball season without incident, and participated in off season strength and conditioning sessions offered in the fall. In October, the student-athlete began experience nausea and vomiting after exertion. 100 mg of Solu-Cortef was administered intramuscularly and the athlete was taken to an urgent care facility by the coaching staff. After unsuccessful treatment at the urgent care facility, the athlete was transported to the local emergency department. The athlete was discharged after two nights of observation and instructed to follow up with her primary endocrinologist. The next January, the student-athlete experienced heat exhaustion and was given a 100 mg of Solu-Cortef before being transported to the emergency department. The athlete experienced a final incident in May, suffering from nausea and diarrhea. Following treatment at the emergency department, the athlete was discharged the same day. Based off of the incidents from the past year, the athletic training staff formulated further policies and procedures for expediting care of the student-athlete. **Uniqueness:** While CAH is a relatively common condition in the United States and the United Kingdom, there is no quality research addressing the management of athletes suffering from CAH. There are very likely multiple athletes participating in sports suffering from CAH, but possibly do not have such severe cases. **Conclusions:** Student-athletes suffer from a number of stressors throughout their life. When caring for an athlete undergoing multiple stressors, it is paramount to understand any underlying conditions that may exacerbate these stresses. Cortisol is an important component of the body's response to injury, and athletes who are cortisol compromised must be given special accordance to insure that they are cared for properly. Also, pre-participation examinations can identify both common and uncommon pre-existing conditions. Sports medicine professionals need to be prepared to develop adaptable policy and procedures, in collaboration of all necessary stakeholders, for appropriate management and safe participation for the student-athlete.

Diagnosis and Management of Acute Posterior Multifocal Placoid Pigment Epitheliopathy in a Collegiate Baseball Player: A Case Study

Fiesler T, Warner BJ, Gallegos DM, Wade ME, Cage SA: University of Texas, Tyler, TX; Grand Canyon University, Phoenix, AZ; AT Still University, Mesa, AZ; Christus Trinity Mother Frances Health System, Tyler, TX

Background: During post season travel, a 22-year-old baseball player reported to the medical staff complaining of blurred vision in his left eye. Upon evaluation, the patient was found to be suffering from bilateral scleritis. The patient reported no pain associated with the inflammation, but did make mention of being able to feel increased intraocular pressure. The patient could not recall a specific incident that would have caused injury to his eye, but noted that he had been doing lawn work earlier in the week, potentially exacerbating his seasonal allergies or struck in the eye by a foreign body. **Differential Diagnosis:** Allergic reaction, Corneal abrasion, Foreign object in sclera. **Treatment:** Day 1, upon evaluation the patient was given tetrahydrozoline hydrochloride drops to administer as needed. Following two rounds of administration, the patient reported some relief in the sensation of pressure but no improvement in blurred vision. Over the next 6 days, the patient continued use of tetrahydrozoline hydrochloride and did not participate in team activities that involved hand-eye coordination. A plan was made to refer the patient to the team physician for further evaluation. Day 7, patient was evaluated by the team physician, who was able to rule out a corneal abrasion through use of fluorescein eye drops and cobalt blue light. Following evaluation the patient was immediately referred to an ophthalmologist. The ophthalmologist performed a full eye exam and found both anterior and posterior cataracts in the left eye. The ophthalmologist also noted multiple creamy placoid choroidal lesions in both eyes measuring 400-800 micrometers in diameter. After ruling out a retinal tear or detachment, the patient was diagnosed with acute posterior multifocal placoid pigment epitheliopathy. The patient was placed on a 5-day round of oral prednisone to speed recovery. Day 14, after completion of medication, a follow-up appointment with the ophthalmologist revealed placoid lesions had begun to heal and blurred vision was improving. A plan was made for a further follow up the following month. In the interim, the patient reported no increase in discomfort and gradual improvement of blurred vision. Day 55, patient underwent a second follow up evaluation with ophthalmologist which revealed a nearly complete resolution of lesions. The patient's vision returned to near normal (20/30 vs. 20/20), with only minor damage to the optic nerve. The patient was then cleared in full team activities upon the beginning of the next academic year. **Uniqueness:** "White-dot" syndromes are a collection of rare conditions affecting the deep retina or choroid with a common set of signs and symptoms. A PubMed and Google Scholar search of the terms "Acute Posterior Multifocal Placoid Pigment Epitheliopathy" and "Athlete" yielded no results. While acute posterior multifocal placoid pigment epitheliopathy is an idiopathic condition, the lack of a mechanism of injury confounded initial diagnosis. **Conclusions:** It is paramount that all sports medicine professionals obtain an accurate history at the time of initial evaluation. If there is no mechanism of injury present, the clinician must exhaust all diagnostic options until a cause of symptoms can be found. Had the patient in this study not been referred in a timely manner, there may have been further damage to the optic nerve resulting in a significant loss of vision.

Competitive Anxiety Leading to Recurrent Vomiting in a Middle School Football Player

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Background: On September 1st, 2016, a 12-year-old male football player suffered multiple episodes of vomiting during a game. The athlete stated he ate fast-food before the game and hadn't been feeling well within three days prior. The athlete's father came to the sideline and stated that the athlete has a history of "exercise-induced vomiting." After about 15 minutes, he felt better and played the remainder of the game with no complaints. Five days later, he explained he still wasn't feeling well, stating he vomited multiple times over the weekend and at the start of practice that afternoon. The athlete also stated that he occasionally vomits during school. Following an examination by the family's pediatrician, he was told to rest one week, and return to practice on September 8th. Twelve days later, the athlete vomited at practice without provocation. Finally, following another episode of vomiting 14 days later, he stated that he experiences anxiety. This was discussed with the head coach, who trialed a "no yelling" practice later in the week, and the athlete did not vomit. When the Athletic Trainer discussed this situation with the parents, the father recalled previous athletic scenarios in which the athlete had vomited, possibly due to anxiety. **Differential Diagnosis:** Gastroenteritis, food poisoning, post-nasal drip, food allergy, anxiety. **Treatment:** 25 days post-onset, the athlete was referred by the AT to a licensed sport psychology professional (SPP) who is also a licensed professional counselor. The SPP noticed signs and symptoms mimicking those of competitive state anxiety and outlined a mental skills program that included mindfulness exercises, diaphragmatic breathing, goal setting, and relaxation training. Following the first meeting between the athlete and SPP, the mother stated her son came out a "new kid." During the next competition, 29 days later, the athlete stated he did not feel nervous or have any urge to vomit. The AT spoke to the parents, who reported

seeing a positive impact on their son's overall well-being. The athlete completed three sessions with the SPP from September 25th to October 24th and has experienced no vomiting episodes at practice or in competition since the first meeting. The parents decided to continue sessions on an as-needed basis. **Uniqueness:** The case is unique due to age the group, mechanism, incidence and intervention. Anxiety and its psychological variables have garnered much attention in sport psychology, but there is a paucity of research examining adolescent competitive and performance anxiety interventions. Research discusses most performance anxiety scenarios occurring within the elite setting, or high-risk settings, as opposed to middle school-aged environment. It was discovered that this athlete had previously fumbled the ball, leading to thoughts of continued poor performance, disappointing teammates, and low self-efficacy. Further investigation revealed that the athlete had previously been permanently replaced for a poor performance, which was hypothesized to contribute to his fear of failure, manifesting in competitive state anxiety. **Conclusions:** Adolescent athletes should be regularly monitored for signs and symptoms of performance anxiety and other psychosocial constructs (e.g., lack of motivation, apathy, withdrawal, etc.). With greater expectations at the lower-level of play, children are experiencing sport-specific performance anxiety and high levels of somatic arousal, worry, and/or concentration disruption when exposed to stressful competitive sport situations. This scenario may be creating negative relations with self-esteem. The importance of AT recognition of psychosocial constructs in athletes may lead to referrals to appropriate professionals and thus, more appropriate intervention and treatment protocols. Training programs for coaches that enforce more positive, and less stressful competitive sport situations should be considered. The positive impact of sports psychologists, even within the adolescent setting, needs to be stressed as well.

Idiopathic Thrombocytopenic Purpura in a Male High School Basketball Player

Lynch M, Lysuik A, Lawrance SE: University of Indianapolis, ndianapolis, IN; St. Vincent Sport Performance, Indianapolis, IN; Purdue University, West Lafayette, IN

Background: A 15-year-old, male, basketball player with a history of mild ankle sprains presented with mild petechiae on the lower leg and ankle the day after a game and having his ankle taped. The next day, the athlete presented with moderate petechiae up the lower leg to the knee. The Athletic Trainer recognized the petechiae and immediately called the parents of the athlete. He was referred to the hospital where a Complete Blood Count (CBC), complete metabolic panels, chest radiograph, and testicular ultrasound were performed. By the time he reached the hospital, the athlete had developed purpura, which are large areas of hemorrhaging under the skin that occur when platelet counts are under 10,000. After initial evaluation, the athlete's acne medication dosage level was adjusted and a 3-week prescribed no-contact rest period was instituted. The athlete continued attending school, but was not allowed to participate in practice activities due to risk of spontaneous internal bleeding. Approximately one week later, the athlete developed a severe headache and was rushed to the hospital. Blood tests performed at that time showed an elevated platelet count and ruled out the possibility of a stroke or internal bleed. Over the next two weeks, the athlete's platelet count stabilized to a normal level and he was able to return to practice activities approximately three weeks after the initial condition was evaluated. **Differential Diagnosis:** Leukemia was the initial and main reason for concern with the petechiae and purpura, but was ruled out by the other tests performed at the hospital, which had all come back negative. The confirmed diagnosis was Idiopathic Thrombocytopenia Purpura (ITP). **Treatment:** Initial blood tests results showed a low blood platelet count under 5,000, while normal is considered 150,000 or higher. The athlete was taking Bactrim for acne, and had been taking it for 3 weeks prior to this incident. Physicians at the hospital were unsure if Bactrim was the cause of the ITP, because they had previously not seen the condition in someone his age. The athlete was then instructed to immediately cease using Bactrim for acne and began a no-contact rest protocol. Over time, normal blood platelet levels returned. The athlete had less than 3.3% of normal platelet values, which put him at risk for spontaneous internal bleeding, so all contact was limited during his recovery. **Uniqueness:** This case is unique because of the rarity of ITP. In children, there are 50 cases per 1 million people each year. Typically, acute ITP occurs in children under 10 years old, or chronically in adults over 20. **Conclusions:** A 15-year-old high school basketball player with mild amounts of petechia in the lower leg, initially thought to be a skin rash, turned into a significant amount of petechia and purpura within 24 hours. He was referred to the hospital where they discovered his blood platelet counts were below 5,000. He was taken off his acne medication, which seemed to be the cause of his ITP. Within 1 week his platelet counts were normal, and within 3 weeks he was able to return to play. Clinical Application: Athletic trainers should be aware of the signs of ITP, such as unusual petechiae, purpura, epitaxis, and other small wounds that are not clotting as quickly as it should. This could be a sign of a more significant underlying condition requiring further medical evaluation and treatment.

Graves' Disease in a 17-Year-Old Football Player

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Background: A 17 – year – old male high school football player with a history of ADHD and a recent 76 – pound weight loss over the summer, presented with a rapid heart rate and the inability to catch his breath after walking into school. Patient is 6 feet tall and 185-pounds. Direct family history includes, insulin resistance and stroke. Patient was not cleared to participate in football at the start of football season due to a 5th metatarsal fracture. 7 days after the first episode, the patient complained of a "racing heart" while sitting in class. Patient's heart rate was 140 bpm. Three days after the second episode, the patient had another episode while running outside. The Athletic Trainer referred the patient to his primary care physician, where he was then referred to a pediatric cardiologist because of tachycardia. He received an EKG, echo, and a partial stress test that could not be finished because of a heart rate exceeding 250 bpm. The Cardiologist could find nothing abnormal about the heart. He was then referred to endocrinologist that tested blood, the thyroid, and vitals. The normal volume of the thyroid is 10 – 15 ccs; the patient's thyroid was four times the normal volume. Blood tests were conducted to test TSH levels, along with T3 and T4 levels. TSH was 0.5 uIU/mL with the normal range being 0.5 – 4.7 uIU/mL, but T3 and T4 levels were well within the normal range at 5.0 pg/mL and 1.14 ng/mL. Patient was recommended to not play football because of the elevated heart rate. **Differential Diagnosis:** Supraventricular Tachycardia. **Treatment:** The TSH level of 0.5 uIU/mL obtained from the blood test confirmed that the patient suffered from Graves' Disease. Three 10 mg Methimazole per day were administered to the patient but was tapered to one pill per day. One 25 mg Atenolol per day was administered to the patient to treat chest pain, high blood pressure, and prevention of heart attacks. The patient is allowed to participate in physical activity, but he cannot let his heart rate consistently remain about 140bpm by doing continuous activity. The patient is not permitted to return to football because this is an outdoor sport played in the fall in the southern United States and this can cause heart rate to increase rapidly when participating in physical activity. The patient gets blood work every 3 months and medication continues to be adjusted as needed. **Uniqueness:** The cause of Graves' Disease is considered unknown because it is an autoimmune disease. It typically effects women over the age of 20 and is hereditary. In this case however, there is no family history of Graves' Disease on either side of the family and the patient is a 17 year old male. Additionally, Graves' Disease is estimated to effect 2 – 3% of the world's population. **Conclusions:** It is important for athletic trainers to recognize symptoms of Graves' disease before the disease progresses to the point where congestive heart failure or excessive hyperthyroidism can occur. Athletic trainers need to continue to provide doctor referrals for internal medical conditions, while increasing knowledge about internal medical conditions signs and symptoms. Although patients may have no history or previous issues with a disease, it should certainly not be disregarded.

Malaria - Treatment and Athletic Performance Considerations in a Division I Track and Field Athlete

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Background: A 20-year-old female track and field athlete from West Africa underwent a pre-participation physical examination on 1/15/16. During her exam, her questionnaire and exam reveled that she was undergoing treatment for a malaria infection before she traveled to the United States. She started taking artemether 20mg and lumafantrine 120mg on 1/14/16. An infectious disease specialist was consulted because the student athlete was still febrile and had body aches. At this time, the student athlete was not cleared for participation. Provided that she felt better, the student athlete was allowed to begin training 48-hours after the completion of her medication. She went on to complete in the indoor and outdoor track and field seasons and additional competition over the summer without any issues or recurrence of symptoms. **Differential Diagnosis:** Influenza, hepatitis, other general viral or bacterial infection, malaria, mononucleosis. No other examination or evaluation was required at the time of initial evaluation. **Treatment:** Antiparasitic medication to treat the plasmodium-falciparum infection included artemisinin derivative: artemether, and Lumafantrine. The student athlete was prescribed four tablets, BID at 0, 8, 24, 36, 48, and 60 hours from discovery of infection. After the course of medication, the infection went into remission **Uniqueness:** The CDC estimated 198 million malaria infections worldwide in 2013, and over 500,000 resultant deaths. In the United States, however, only 1,500 cases are diagnosed each year. Athletes from malaria prone regions often present to our particular athletic training facility. **Conclusions:** The importance of an accurate physical exam and knowledge of a broad range of infectious disease cannot

be overstated. In this case, a consultation with a specialist was needed to assure that this student athlete was allowed to safely begin participation at the NCAA Division I level. Student athletes traveling to and from Sub-Saharan Africa and Southern Asia should be screened for malaria and other regional pathologies.

Lipdystrophy and Diabetes in Women's Collegiate Soccer Player

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Background: 18 yr-old Canadian female soccer player presented to pre-participation examination with diagnosed Type 2 Diabetes secondary to Congenital Generalized Lipodystrophy. Athlete stated she was diagnosed with Diabetes in July and Lipodystrophy at 6 months of age. Her medical records indicated at her 4-year old appointment, her insulin levels at the time were elevated at 116. She demonstrated normal physical appearance of lipodystrophy, consisting of absence of subcutaneous fat. At 4-year old check-up, she presented with acanthosis nigricans in her neck and axillac. At her 5-year old check-up, she was diagnosed with hypertrophic cardiomyopathy with trace tricuspid regurg and pulmonary insufficiency. The following year, her triglyceride levels were elevated at 2.58 and her cholesterol/HDL ratio was elevated at 4.2. At age 7, she reported with polydipsia and polyuria. Her insulin levels increased to 203 and her triglycerides levels remained elevated. She also was diagnosed with normocytic anemia with decreased levels of hematocrit. Physician examination revealed presentation of acromegaloid on the head and neck, muscular hypertrophy and phlebomegaly. At the age of 8, she showed mutations in her genetic testing of AGPAT2 gene associated with Type 1 lipodystrophy. Blood work showed increased insulin to 264 and her cholesterol as well as triglycerides were normal. At the age of 9, she had surgery for an umbilical hernia repair. At 10 years old, she presented with venous prominence associated with lipodystrophy. Her bone age reports 12 years old. Her blood work showed her glucose levels to be 5.2 and her triglycerides level at 1.58 Athlete was discharged from the clinic at age 11. Her recent blood work for glucose screening revealed her hemoglobin levels low at 116 leading to her hematocrit levels to be low at 0.35. Her glucose was elevated at 28 and her CK was elevated 543. Her triglyceride level was high at 3.88 and her cholesterol was 5.06. Her doctor prescribed her metformin at 500mg and lantus at 22 units and Humalog at 10-12 units. **Differential Diagnosis:** Congenital Generalized Lipodystrophy with Type 2 diabetes, Centrifugal lipodystrophy, prediabetic **Treatment:** She consulted with team nutritionist and developed a diabetic diet for athletes. She was given a meal plan consisting of 6 meals a day with 100-120 g of protein and 85g of carbohydrates a day. Her glucose level should be 8-10 after meals. She is to log her food every week and report back to the nutritionist for the first month to make sure she is on track. Once a pattern is set with her eating habits, she will only log her food on game days. After a month of just game day logs, if she feels comfortable with her nutrition habits, she does not need to log her food. **Uniqueness:** Congenital Generalized Lipodystrophy is an inherited autosomal recessive disorder. This disorder is characterized with lack of fatty tissue leading to fat storage in other parts of the body. Abnormal fat storage can lead to variety of medical concerns including high levels of fats circulating in the body and insulin resistance. Athlete's doctors report she has been doing much better with management and progression than most individuals with lipodystrophy. **Conclusions:** Athletes with diabetes have to keep in mind the importance of glucose levels due to the consequences of hyperglycemic episodes and other factors leading to diabetic coma if levels are not within normal limits. Also, learning about lipodystrophy is important due to one of the correlating factors being hypertrophic cardiomyopathy, the most leading cause of cardiac death in young athletes.

Exertional Rhabdomyolysis and Return to Sport in a NAIA Collegiate Men's Soccer Athlete

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Background: A 20-year-old men's soccer defensive center back reported to the athletic training facility in January 2016 recovering from exertional rhabdomyolysis (ER) after a self-referred emergency department visit in December 2015. At the completion of soccer season in November 2015, he became ill and was diagnosed with "walking pneumonia". He was given antibiotics and instructed to rest for three weeks, at which time he participated in a resistance training program for three consecutive days. Patient completed workouts targeting triceps/back, biceps/chest, and legs, respectively, for a minimum of 60 minutes each day. On day three (leg day), he felt significant biceps pain and stiffness. On day four, he described his legs as "shot". The following day he could "barely walk" and began to notice dark urine. In the middle of the night, he woke up to use the bathroom and described his urine as black in color. The patient self-referred to the emergency room early in the morning on day six with these symptoms and was admitted for the next two days. **Differential Diagnosis:** Delayed onset muscle soreness, dehydration, ER **Treatment:** Due to creatinine kinase levels at approximately 90,000 U/L and elevated liver enzymes, the patient was diagnosed with ER. Once discharged, he followed up with his primary care physician (PCP) who trended patient's levels back down to normal range and cleared him to begin light aerobic activity. He followed a gradual progression from bike to elliptical to running with the athletic trainer. Activity, symptoms, and workload measured by metabolic equivalent of a task (MET) minutes were tracked daily to ensure patient was progressing appropriately. Approximately three weeks into the progression, once running began, patient started complaining of muscle twitches and, what he described as, "nerve pain" throughout his body. The progression was altered during this time as his PCP referred him to a neurologist who ordered a comprehensive metabolic panel, nerve conduction study, and MRI which were all negative for pertinent abnormalities. The progression was restarted once cleared from the neurologist with the focus being primarily on interval workouts and participation in off-season soccer practices but his symptoms persisted. Patient spent the summer months at home remaining active in cardio training and soccer activities to prepare for preseason despite his symptoms. When the patient returned to campus in August, he reported continued fatigue and muscle twitching and was referred to a different physician with experience treating ER for a second opinion. The physician believes the patient has an underlying myopathy, McArdle disease, a deficiency of key enzymes in muscle metabolism, which made him susceptible to getting ER and would explain his prolonged symptoms. **Uniqueness:** The case primarily focuses on how athletic trainers could perform prevention tasks and provide safe return to play (RTP) guidance. The RTP progression was developed and altered based on the patient's symptoms and workload. Using MET minutes is an easy and beneficial method for athletic trainers to measure/track workload when progressing a patient across several types of activities. Athletic trainers should be aware of underlying conditions that could be present if symptoms persist during a RTP progression. **Conclusions:** The patient is currently participating fully in his soccer season and is playing full 90 minute games. He complains of occasional muscle soreness, twitching, and fatigue. Since ER itself is not well defined in literature, there is very little evidence of a safe and structured RTP protocol for these patients. Athletic trainers must be prescriptive in RTP protocols, especially following periods of inactivity. In the presence of prolonged symptoms after a diagnosis like ER, consider further workup for underlying myopathies or other conditions such as McArdle disease.

Prevalence of Exercise-Induced Bronchoconstriction in Collegiate Women's Basketball

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Context: The prevalence of respiratory conditions, including asthma and exercise-induced bronchoconstriction (EIB), varies widely amongst college athletes. Asthma is a chronic respiratory condition characterized by bronchiole constriction with airway inflammation; whereas, EIB is acute bronchiole constriction secondary to exercise. Up to approximately 20% of the general population, and 90% of those with asthma, have EIB. Currently, there is a lack of evidence regarding the prevalence of EIB in collegiate athletes. **Objective:** The purpose of this investigation was to systematically asses EIB rates in collegiate women's basketball athletes. **Design:** The descriptive study was completed from analysis of spirometry values obtained from women's collegiate basketball athletes who volunteered to engage in the research. **Setting:** Data were collected during a single visit to the human performance laboratory. Results were analyzed by a registered respiratory therapist. **Patients or Other Participants:** Testing was performed on 12 NCAA Division II women's basketball athletes (Age: 20.0±2.3 years; Ht: 69.1±3.0 inches; Race: Black: 2, Caucasian: 10). **Interventions:** No athlete self-reported asthma, thus all were permitted to complete the EIB protocol, which aligned with the American Thoracic Society (ATS) guidelines. Athletes underwent a baseline spirometry test to determine FEV1 values, which were taken in duplicate. All athletes exceeded 70% of predicted FEV1 values, which was required to continue testing. Baseline FEV1 values were used to calculate target ventilation (35*FEV1*0.5 and 35*FEV1*0.6). Athletes underwent a treadmill exercise protocol which progressed in 1 minute increments until the intensity elicited a response satisfying

target ventilation and placing the athlete in an 80-90% predicted maximal heart rate range. Athletes continued exercise at that intensity for 4 minutes. Post-exercise, spirometry testing was performed at 2, 5, 10, 15, and 20 minutes. If FEV1 values dropped greater than 10% from baseline at any post-exercise time point, testing was terminated. Values were assessed by the respiratory therapist to determine diagnosis of possible EIB. **Main Outcome Measures:** The present investigation focused on values obtained from spirometry testing (Examples: FEV1, FVC, FEV1 / FVC, Predicted values) to determine prevalence of EIB in collegiate women's basketball athletes. **Results:** Of the athletes tested, 0 reported pre-existing asthma or EIB, and all achieved greater than 70% of predicted FEV1 values at baseline. However, five of the 12 athletes (41.67%) failed to obtain 90% of their baseline result at one of the post-test time points (16.4 ± 2.8); an indication of EIB. Values were not conclusive in one subject. **Conclusions:** These findings should be used to raise awareness for the potential of undiagnosed asthma and EIB, and to underscore the need for screening of pulmonary conditions in athletes.

Master's Poster Award Finalist

Epidemiology of Sudden Cardiac Death in American Youth Sports

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Context: Sudden cardiac death (SCD) is the leading cause of sport-related death in collegiate and secondary settings; however, little epidemiological data exist on the incidence of SCD in American youth sport prior to secondary school athletics. **Objective:** To describe the epidemiology of SCD in organized American youth sport. **Design:** Descriptive study. **Setting:** Organized American youth sport. **Patients or Other Participants:** Youth athletes who suffered SCD during sport participation. **Data Collection and Analysis:** SCD information between 8/1/2007 and 12/31/2015 was obtained via LexisNexis and other publicly available news or media reports. Total youth sport participation rates from 2007-2015 were provided by the Sport and Fitness Industry Association™. Cases of SCD that occurred in youth athletes <18 years of age in organized sports (non-high school sanctioned) were included. Athlete age, gender, ethnicity, date of death, event type, sport, and speculated cause of death were examined. Data are presented as deaths per year, percent (%) of total cardiac deaths, and deaths per 10,000,000 participants. **Results:** From 2007-2015, 34 cases of SCD (mean = 4 deaths per year) were reported in American youth sports. The average age of SCD was [mean ± SD] 13 ± 2 (range = 9-17) years. The overall incidence rate was 1.4 per 10,000,000 participants. Males (79%, n = 27/34) accounted for nearly 3.8 fold more SCDs than females (21%, n = 7/34). More Caucasian athletes (53%, n = 18/34) died than African Americans (35%, n = 12/34), or Hispanics (6%, n = 2/34), and those cases in which ethnicity was not available (6%, n = 2/34). When broken down into three-year segments, 5 SCDs occurred from 2007-2009, 11 from 2010-2012, and 18 from 2013-2015 with incidence rates of 0.6, 1.4, and 2.2 per 10,000,000 participants respectively. The deadliest year was 2015 with an incidence rate of 3.5 per 10,000,000 participants. A greater number of SCDs occurred during practice (62%, n = 21/34) than during competition (38%, n = 13/34). The highest number of SCDs (44%, n = 15/34) occurred during basketball. Of these basketball SCDs, African-American athletes experienced a higher number of SCDs (60%, n = 9/15) than Caucasian athletes (40%, n = 6/15). **Conclusions:** From 2007-2015, 34 youth athletes experienced SCD while playing organized sport, with an increasing incidence of SCDs in more recent years. With an overall incidence of 1.4 SCDs per 10,000,000 participants, these rates are lower than those reported in secondary school and collegiate sports. Although we are not able to estimate deaths per activity exposure, our findings are similar to data from collegiate and secondary school in that youth male basketball athletes carry the greatest risk of SCD. Continued examination of youth sport SCD is needed to improve data quality related to incidence and participation rates in order to ultimately enhance health and safety guidelines.

Effectiveness of a Hydration Educational Intervention on Semi-Professional Female Tackle Football Players

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Context: Several studies have examined the effectiveness of a hydration educational intervention on improving hydration knowledge, hydration habits, and exercise performance, yet there are no studies on the effects of a hydration educational intervention with female tackle football players. **Objective:** To determine the hydration knowledge, hydration status and behaviors of female semi-professional American football players before and after an educational hydration intervention. **Design:** Cohort study **Setting:** Field setting, football field **Patients or Other Participants:** Twenty-two females (age: 30.5 ± 5.5 yrs, height: 164.4 ± 15.0 cm, weight: 76.6 ± 18.8 kg) from the same tackle football team volunteered for this study. Participants consisted of players of various offensive and defensive football positions. **Interventions:** Participants were observed Week 1 (Initial Observation) for 2 practices then given an educational intervention (EI) Week 2 in small groups of 2-4 participants. The EI was based on their individual hydration status and behaviors during the Initial Observation phase. They were then observed again Week 3 (Follow-Up Observation) for 2 more practices. **Main Outcome Measures:** Percent body mass loss(% BML), urine specific gravity (USG), and urine color (U_{col}). Each participant also completed a pre- and post-EI Hydration Awareness Questionnaire (HAQ), Hydration Habits Questionnaire (HHQ) and a post-study Exit Questionnaire (EQ). Descriptive data (mean ± SD) were calculated for all measures. Hydration measures were measured across days with a repeated measures ANOVA. Pre-post-EI measures were analyzed with dependent t-tests, and Pearson correlations were used for comparisons of HAQ, EQ, and hydration indices(α, $P < 0.05$). **Results:** All trials took place during evening practices over the course of 3 weeks (wet bulb globe temperature 20.2 ± 1.2°C). No differences were found with pre-practice Ucol from pre-EI (3 ± 2) to post-EI (4 ± 2; P = .507). Pre-practice USG was also similar between pre-EI (1.015 ± .008) to post-EI (1.017 ± .007; P = .181). There were significant differences in total HAQ scores as a result of the EI (P = .001). In particular, the question asking what it means to be hydrated significantly improved from pre- to post-EI (P = .021). According to the HHQ, 86% of the participants believed drinking fluids while playing sports was very important. The participants' %BML across all 4 days was -0.1 ± 0.5%, indicating participants maintained their hydration status during practices. There were no significant relationships between the response to the EQ question asking if they did a good job of drinking fluids during practice and their % BML (r = .442, P = .087) nor their 4-day average USG (1.017 ± .006, r = -.233, P = .322). **Conclusions:** There were improvements in hydration awareness as a result of the EI. However, the lack of changes in hydration measures demonstrates the EI was not effective in changing the football players' hydration behaviors. Overall, the participants were adequately hydrated during this study. Athletic trainers should assess their athletes' hydration status to determine which groups may benefit from an educational intervention.

Dietary Sodium Intake and Sweat Sodium Losses in Division II Collegiate Football Players During Pre-Season Training Camp

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Context: Sweat rates, sodium concentration and sodium losses have been reported in football players, but dietary sodium intake has not. Heavy, salty sweaters may need a high dietary sodium intake to prevent hypovolemic hyponatremia. **Objective:** To calculate daily sodium intake of football players over three consecutive days (5 practices) and make comparisons to their measured sweat sodium loses during practices on those days. Additionally, to evaluate players' blood electrolytes, percent change in plasma volume (%ΔPV), urine osmolality and changes in body mass from baseline measures. **Design:** Observational field study. **Setting:** Preseason of one collegiate football team. **Patients or Other Participants:** Fourteen players (age = 21 ± 0.9, mass = 107.0 ± 24.7 kg, height = 182.1 ± 21.3, BSA = 2.2 ± 0.3 m^2, and BSA/Mass = 222.0 ± 22.0 $cm^2 \cdot kg^{-1}$) participated. **Interventions:** Blood and urine samples were taken at baseline and then in the morning of 3 consecutive days during week 2 of training camp. Blood was analyzed for Hb, Hct, and electrolytes. Urine was analyzed for osmolality, and body weight was recorded before and after practices with players in dry shorts. Sweat rate was calculated by change in body weight adjusted for fluid consumed and urine produced. Sterile sweat patches were used to collect sweat samples from the forearm and low back. The patches were removed 20-40 min into practice, placed in sterile tubes and centrifuged. Sweat was analyzed for sodium by ion-selective electrode. All consumed food and beverages were reported by players via immediate photos and text descriptions.

Diets were analyzed using a common nutrition analysis software. **Main Outcome Measures:** Sweat Na^+, K^+, and Cl^- concentrations, sweat rate, dietary Na^+, NaCl, blood electrolytes (Na^+, K^+, Cl^-), urine osmolality, %ΔPV, and body mass. **Results:** WBGT was 79.5 ± 3.4°F over the 3 experimental days. On all experimental days, Na^+ intake exceeded Na^+loss. On Day1, (first two-a-day) Na^+ loss was 4723 ± 1630 mg and intake was 6773 ± 2105 mg. On Day2, (one practice), Na^+ loss was 3012 ± 1319 mg and intake was 5431 ± 2056 mg, and on Day3, (two-a-day) Na^+ loss was 4455 ± 1933 mg and intake was 7324 ± 3217mg. Individual sweat rates varied ranging from 0.59-5.96 L/hr. Mean sweat sodium concentration was 35.4 ± 13.8 mmol/L and ranged from 14-77 mmol/L. %ΔPV was higher than baseline ($p \leq 0.05$) on Day 1 (9.1 ± 17.9%) and Day 2 (10.1 ± 10.1%). No differences existed across days in blood electrolytes, body weight or urine osmolality which ranged from 674.5 ± 181.8 mOsm/kg-732.1 ± 182.5 mOsm/kg. **Conclusions:** All player's dietary sodium intake was greater than measured sweat sodium losses. The expansion of PV, no changes in blood sodium, urine osmolality or body mass indicates that the players maintained sodium and fluid balance during these 3 days and 5 practices. The subjects were educated on the importance of high dietary sodium consumption during preseason potentially assisting in preventing hypovolemic hyponatremia as previously reported.

The Relationship of Thirst to Hydration Markers Before and After Exercise

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Context: Thirst is potentially a simple indicator of hydration status during exercise; however, relationships between ratings of thirst perception and fluid losses remain unknown across a range of hydration states. **Objective:** To describe the relationship of thirst perception to hydration markers across a range of hydration states pre and post exercise. **Design:** Randomized controlled trial. **Setting:** Research laboratory. **Patients or Other Participants:** Ten healthy, recreationally active males (Mean ± SD; age 22 ± 3 years; height 179 ± 6 cm; body mass 73.5 ± 10.6 kg; body fat 11.7 ± 3.8%; VO_{2max} 54.08 ± 5.26 $ml \cdot kg^{-1} \cdot min^{-1}$). **Interventions:** Participants completed four randomized, counterbalanced exercise trials on a motorized treadmill in a hot environment (35.2 ± 1.1°C, 31.4 ± 6.3% relative humidity). Participants started two trials in a euhydrated state and two trials in a hypohydrated state. Pre exercise hypohydration was achieved with 22-hour fluid restriction. Fluid was provided to replace sweat losses in one euhydrated trial only. Fluid was not replaced in the other three trials (Dehydration trials) to allow body mass loss (BML) ~5%. Exercise included intermittent cycles of walking, running, and rest. **Main Outcome Measures:** Thirst perception (Thirst) was measured using a 1-9 point Likert scale immediately pre-exercise (PreEx) and immediately post-exercise (IPE). Nude body mass was taken 24-hours before exercise, PreEx and IPE; BML was calculated as difference from a baseline measure for PreEx and IPE. Blood plasma osmolality (P_{osm}) and change in plasma volume (P_{vol}) were measured at PreEx and IPE. Change in Thirst, P_{osm}, and P_{vol} was calculated from PreEx and IPE. Piecewise regression analysis was performed, and a break point was used to separate low (Low; <4) and moderate-high (High; ≥4) levels of Thirst and Thirst change (IPE-PreEx). **Results:** PreEx, there was a positive relationship of Low Thirst to BML ($R^2 = 0.287$, $p = 0.006$) indicating lesser thirst associated with a smaller PreEx BML. BML at IPE was 3.93 ± 0.99% for the Dehydration trials. At IPE, there was a positive relationship between Low Thirst and BML ($R^2 = 0.648$, $p = 0.009$); and High Thirst and BML ($R^2 = 0.378$, $p < 0.001$). IPE Low Thirst was positively related to IPE P_{osm} ($R^2 = 0.142$, $p = 0.037$). For change in Thirst, High Thirst change was positively related to P_{osm} change ($R^2 = 0.317$, $p = 0.010$), and BML ($R^2 = 0.356$, $p = 0.006$). There was no relationship between P_{vol} and any level of Thirst at any time point or Thirst change. **Conclusions:** These results suggest that an individual with a low level of thirst before exercise is likely not significantly hypohydrated, and that an individual with a moderate-high level of thirst following exercise is likely dehydrated. Additionally, a change in thirst was related to a change in hydration markers. These results suggest that thirst may be a viable indicator of hydration state before and after exercise.

The Association of Competition Volume, Club Sports, and Sport Specialization With Previous Lower Extremity Injury in High School Athletes

Post EG, Bell DR, Trigsted SM, Schaefer DA, Miller MC, Pfaller AY, Hetzel SB, Brooks MA, McGuine TA: The University of Wisconsin-Madison, Madison, WI

Context: Intense, year-round participation in organized sports in increasingly common among youth athletes. Sport specialization has been associated with previous injury history in clinical settings and in a limited number of high schools and sports. However, the impact of competition volume and participating on a club sports team in addition to high school participation on potential injury risk is unknown. Additionally, the association between specialization and injury history in a large sample of high school athletes from a variety of sports has not been established. **Objective:** To determine the association of competition volume, club sport participation, and sport specialization with previous lower extremity injury (LEI) in high school athletes. **Design:** Cross-sectional. **Setting:** High schools. **Patients or Other Participants:** 1525 high school athletes (780 female, age = 16.1 ± 1.1 years old, grades 9-12) from 29 high schools were recruited to complete a pre-season questionnaire. **Interventions:** Subjects completed a questionnaire prior to the start of their competitive season regarding their sport participation patterns and previous injury history. Primary sport competition volume in the previous 12 months was classified as high (>60 primary sport competitions), moderate (30-60 competitions), or low (<30 competitions). Sport specialization status was classified as low, moderate, or high using a widely utilized 3-point specialization scale. **Main Outcome Measures:** Primary sport competition volume, club sport participation, sport specialization classification, and previous history of lower extremity injury. Multivariable logistic regression analyses were used to investigate associations of competition volume, club sport participation, and sport specialization with history of LEI, adjusting for sex. **Results:** Overall, 52.8% of participants reported taking part in a low volume of competition, while 17.2% participated in high competition volume. Approximately half (49.2%) of subjects reported participating on a club sports team in addition to their high school team. Over half (59.5%) of subjects were categorized as low-specialization while 13.4% were classified as highly specialized. A total of 487 subjects (31.5%) reported sustaining a total of 599 previous time-loss LEI. The most common sites of previous LEI were the ankle (43.2%), followed by the knee (23.4%) and the lower leg (9.5%). Subjects with high competition volume (OR: 2.08, 1.55-2.80, $p < 0.001$), who participated in a club sport (OR: 1.50, 1.20-1.88, $p < 0.001$), or were highly specialized (OR: 2.58, 1.88-3.54, $p < 0.001$) had significantly greater odds of reporting a previous LEI than subjects with low competition volume, no club sport participation, or low specialization. **Conclusions:** Participating in high sport competition volume, on a club team, or being highly specialized were all associated with previous LEI, even after adjusting for sex. Youth athletes, parents, and clinicians should be aware of the potential risks of intense, year-round participation in organized sports.

Validity of Twelve Physical Fundamental Movement Skills in Assessing Physical Literacy

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Context: Lack of validity data of physical literacy (PL) interventions raises efficacy questions of these programs. Recent claims of physical skill improvement in children, injury prevention, and commitment to lifelong activity, are associated with PL. However PL tools have yet to be validated. **Objective:** Using group consensus, we determined the face and content validity of twelve skills often used in PL interventions. **Design:** Delphi method using an expert panel. **Setting:** Online **Patients or Other Participants:** Ten (10) experts on physical movement in children volunteered for this study. The experts were stratified throughout our established age groups 25-34 (3), 35-44 (4), and 45 and older (3). Five had Bachelor of Education degrees, two Bachelor of Science, and two had Master's degrees (Education or Science). They listed professions as Physical Education (PE) teacher (5), Administrator in PE settings (2), Coach (1), and Health Care Provider (2). Each had experience with children and movement capabilities. **Interventions:** To establish consensus we presented a previously established PL program used in after-school programs (5-8 year old children) consisting of twelve physical skills that had four specific performance cues. Each skill and cue sets were presented to participants who commented on the "importance" (the skill being a necessity for the child/participant to be taught/learned, and to perform, as a portion of the overall skill) and the "efficacy" (the practicality of judging the cue). Practicality was further defined as clarity of the cue and the ease of judging it. Participants were given the opportunity to suggest cues. Cues that did not obtain an 80% agreement from the first

phase were addressed in phase two. A second round of responses was recorded, with additional write-in cues as options. If there were reasonable options offered in phase one, even for a cue with consensus, we requested input to determine consensus versus the 'write-in' cue **Main Outcome Measures:** We assessed twelve skills divided by Locomotor Skills (Running, Galloping, Hopping, Skipping, Horizontal Jump), Balance and Stability Skills (Balance and Airplane Balance), and Object Manipulation Skills (Underhand Toss, Underhand Catch, Overhand Throw, Kicking (a Ball), Dribbling (a Ball)). **Results:** Nine skills obtained consensus on the first phase, which was maintained following phase two even when considering optional cues. Cues without consensus did not reach consensus when considering the options. The least agreed upon cues were balance related. **Conclusions:** The results show excellent validity for most cues for each skill, without changes due to write in options. Balance skills require more assessment to determine a consensus for measurement in the PL context. Valid measures of PL are available with some skills, which can contribute to understanding the merits of such interventions on health related concerns.

Classroom Brain-Breaks Improve Neuromuscular Control and Physical Fitness Measures in Urban Youth

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Context: Neuromuscular training reduces injury rates and improves neuromuscular control in youth. Widespread implementation of neuromuscular training is limited. Implementing neuromuscular training as a classroom brain-break may be an effective option to expose all children to this type of intervention. It is unknown whether neuromuscular training utilized in a classroom can improve neuromuscular control, as well as physical fitness measures. **Objective:** To evaluate the effect of a neuromuscular training program implemented in a classroom setting on neuromuscular control and physical fitness measures in urban youth. **Design:** Cluster, randomized control trial **Setting:** Field-study **Patients or Other Participants:** Four 5th and 6th grade classes at one urban middle school were randomized into control (CON) or intervention (INT) groups. A random subsample of female participants (n=10 per group) completed testing at the end of the school year (May). **Interventions:** Twenty-minute brain-breaks were implemented in-class for the INT group 3-times per week by athletic trainers (ATs) during the academic year. The breaks consisted of a 5-minute warm-up followed by 10-15 minutes of structured exercise (flexibility, strength, balance, plyometric, agility) progressions with consistent verbal feedback cues. Neuromuscular control and physical fitness measures were evaluated during a single test session in a school gymnasium at the end of the school year (May). Neuromuscular control measures included the Landing Error Scoring System (LESS) and the Balance Error Scoring System (BESS). Participants completed three trials of a standardized jump-landing task that required them to jump forward from a 30-cm box a distance of half their height and jump for maximal height immediately upon landing. Two video cameras recorded the jump-landing from the front and side. These videos were evaluated using the LESS by a single rater, blinded to group. Participants performed a standardized balance task using three stances (double-limb, single-limb, tandem) on two surfaces (firm, foam). Trained raters, blinded to group, evaluated the balance tasks using the BESS. Physical fitness measures included sit-ups, shuttle-run, and long-jump. The maximum number of sit-ups during 30-seconds were recorded. Participants performed two trials of a timed 15.24-meter shuttle-run and long-jump for maximal distance. **Main Outcome Measures:** Separate one-way analyses of variance were used to compare groups on average shuttle-run time, long-jump distance, total sit-ups and average total BESS and LESS scores (alpha = 0.05). **Results:** The INT group (15.0 ± 3.1 sit-ups) performed more sit-ups than the CON group (11.0 ± 4.1 sit-ups)($P = 0.04$). The INT group (9.90 ± 4.2 errors) completed fewer errors on the BESS compared to the CON group (13.8 ± 4.1 errors)($P = 0.04$). No other significant differences were observed ($P > 0.05$). **Conclusions:** Classroom-based neuromuscular training programs performed as a brain-break can improve balance and sit-up performance in 5th and 6th grade female urban youth. Future studies should evaluate the effectiveness of neuromuscular training in a classroom setting within larger populations.

Sport Participation Characteristics Between Suburban and Rural High School Athletes

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Context: Sport specialization, which is defined as year round participation in a single sport, is an increasingly common problem in high school and youth athletes. Sport specialization has been associated with overuse injuries and is more common in larger high schools. However, sport specialization and the characteristics associated with high levels of sport participation have not been compared between suburban and rural high schools. **Objective:** To examine the differences in sport participation characteristics between athletes at suburban versus rural schools. **Design:** Cross-sectional. **Setting:** High schools. **Patients or Other Participants:** High school athletes (n = 353, age = 15.7 ± 1.2 years, 222 females) from four high schools (2 suburban and 2 rural) participated in this study. Athletes were on a school sponsored athletic team in one of four sports (volleyball, tennis, basketball, soccer). The suburban schools (n = 225) had total school enrollments of 1,802 and 622 students while the rural schools (n = 128) had total school enrollments of 443 and 297. **Interventions:** Participants completed a questionnaire prior to the start of their high school sport season. The questionnaire consisted of 1) demographic information, 2) sport specialization scale, and 3) sport participation information. Primary sport competition volume in the previous 12 months was classified as high (>60 primary sport competitions), moderate (30-60 competitions), or low (<30 competitions). Sport specialization status was classified as low, moderate, or high using a widely utilized 3-point specialization scale. **Main Outcome Measures:** Competition volume, sport specialization categorization, hours/week and months/year of sport participation, and participation in a league outside of school. Independent t-tests and chi-squares were used to examine differences between athletes attending rural and suburban schools ($\alpha < 0.05$). **Results:** Athletes at suburban schools were more likely to be classified as highly specialized (n = 85, 36%) compared to athletes at rural schools (n = 6, 7%) ($X^2 = 52.5$, $P < 0.001$). Athletes at suburban schools started playing their primary sport at a younger age (suburban: 7.8 ± 2.9 yrs; Rural: 9.7 ± 3.2 yrs, $P < 0.001$), and participated in their primary sport for more years (Suburban: 7.9 ± 3.1 yrs; Rural: 6.1 ± 3.3 yrs, $P < 0.001$). Athletes at suburban schools participated in their primary sport more months/year (Suburban: 7.6 ± 3.6 mo; Rural: 5.6 ± 2.8 mo, $P < 0.001$) and hours/week (Suburban:15.2 ± 5.1hrs; Rural: 12.9 ± 3.2 hrs, $P < 0.001$) compared to athletes at rural schools. Additionally, athletes at suburban schools were more likely to have a higher competition volume ($X^2 = 16.6$, $P < 0.001$), more likely to play in a league outside of school ($X^2 = 18.4$, $P < 0.001$), more likely to train >8months/year in their primary sport ($X^2 = 27.7$, $P < 0.001$), and more likely to miss times with friends as a result of sport ($X^2 = 10.1$, $P = 0.001$). **Conclusions:** High school athletes at suburban schools are more likely to exhibit characteristics associated with high volume sport participation. Efforts aimed at safe sport participation may need to be targeted to these groups as they seem more likely to exceed current volume recommendations.

A Comparison of the Impact of Sport Specialization on Lower Extremity Injury Rates in Male and Female Adolescent Athletes

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Context: Sport specialization has been shown to be associated with increased risk of lower extremity injuries (LEI) for adolescent athletes in retrospective studies and in clinical settings. However, there is a lack of prospective data on whether sport specialization increases the incidence of LEI equally in both males and female athletes. **Objective:** To compare the incidence of LEI between male and female high school athletes with various levels of sport specialization. **Design:** Prospective cohort trial. **Setting:** Data were collected at 29 Wisconsin high schools during the 2015/16 academic year. **Patients or Other Participants:** Male and female athletes (grades 9-12) in matched sports (baseball/softball, basketball, cross country, soccer, tennis and track). **Interventions:** Subjects completed a questionnaire identifying the sports they participated in during the school year, history of previous LEI, their primary sport and number of primary sport competitions they participated in within the previous 12 months. Sport specialization status was classified as low (LOW), moderate (MOD) or high (HIGH) using a widely utilized 4 item specialization scale. Licensed athletic trainers at each school reported all athletic exposures and LEI that occurred for each subject during each interscholastic sport season they participated in during the school year. **Main Outcome Measures:** The main outcome variable is the incidence of LEI. Analyses included group proportions and median days lost due to injury (Med [IQR 25^{th},75^{th}]. Multivariate Cox Proportional Hazards Ratios (HR, [95% CI]) were calculated to compare the incidence of LEI between each level of specialization and between males and females, while controlling for specialization level, grade, history of previous LEI, sport and the

number of sport competitions **Results:** A total of N=902 subjects (female = 52%, age = 16.1 + 1.1 yrs.) enrolled in the study and participated in 95,444 athletic exposures. Subjects were classified as being LOW (55%), MOD (29%) or HIGH (16%) level of specialization. One hundred forty three subjects (16%) sustained a total of n = 164 LEI that caused them to miss a median of 6.0 [2.0, 16.0] days. Injuries occurred most often to the ankle (32%), knee (29%) or upper leg (11%) and included ligament sprains (38%), muscle / tendon strains (26%) and tendonitis / tenosynovitis (23%). The incidence of LEI for MOD subjects was not higher than LOW subjects (HR = 1.39 [0.89-2.15], p = 0.144). The incidence of LEI for HIGH subjects was higher than LOW subjects (HR = 2.10 [1.32-3.35], p = 0.002).The incidence of LEI for males was no different than females (HR = 0.89 (0.66-1.20) p = 0.452). **Conclusions:** While a high level of sport specialization increases the risk of LEI in adolescent athletes, there was no difference in the rate of injury for males and females regardless of their level of sport specialization.

Effect of Preoperative Sport Participation on Post-Operative Outcomes in Patients Undergoing Knee Cartilage Surgery

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Context: Patients with cartilage lesions are at risk for the development of osteoarthritis. Therefore, repair or restoration procedures are frequently implemented. Exercise is suggested to play an important role in joint health. Sport participation, one form of exercise, is commonly employed. It has previously been observed that post-operative sports participation may improve long-term cartilage restoration outcomes. However, it is unclear if preoperative functional participation, such as sport, provides patients an advantage in post-operative recovery. **Objective:** Our purpose was to evaluate if preoperative sport level affects post-operative outcomes. We hypothesized that patients participating in sport preoperatively would demonstrate better post-operative outcomes. **Design:** Retrospective Longitudinal. **Setting:** Orthopeadic Sports Medicine Clinic. **Patients or Other Participants:** Fifty-four patients undergoing a knee cartilage repair/restoration procedure were identified from a prospective patient registry (Age 33 + 10, BMI 28 + 5, F32/M22). Osteochondral Allograft Transplantation (n = 16), Cell Based Implantation (n = 30), Meniscus Transplant (n = 3), Microfracture (n = 3) and Osteochondral re-fixation (n = 2) were performed. **Interventions:** Based upon the Patient-Work and Sport Preop Questionnaire patients were categorized as sporting(n = 25) or non-sporting (n = 29). Sporting was defined as patients who identified as professional, high-level, or well-trained athletes. Non-sporting was defined as patients who reported sport sometimes or no sport participation. **Main Outcome Measures:** The International Knee Documentation Committee Questionnaire (IKDC) was completed at 6-months, 1-year, and 2-years. At 2-years the Global Rating of Change (GROC) and a satisfaction questionnaire were completed. The 15-point GROC scale (range -7 to 7) evaluated how patients perceived they had changed from before surgery to 2 years. A repeated-measures ANOVA was used to compare IKDC scores over time between sporting and non-sporting groups. GROC scores were categorized as meaningfully improved (> 3) and not improved (≤ 3). An odds ratio was calculated to determine the odds of reporting improvement at 2-years between sporting and non-sporting patients. **Results:** There were main effects for group (p = 0.01) and time (p = 0.00) with no group-by-time interaction. Mean scores by group were (Sporting = 58.47 + 23.92, Non-Sporting = 46.58 + 22.21). Mean scores for time were (Pre = 37.02 + 15.23, 6m = 55.79 + 17.73, 1yr = 58.37 + 22.12, 2 yr = 58.91 + 22.13). Sporting patients had 4.33 (95%: 0.91,20.6) greater odds of reporting improved change at 2-years when compared to non-sporting patients. Irrespective of group, the surgery met the majority of patients' expectations (Sporting = 88%, Non-Sporting = 76%). **Conclusions:** Although both sporting and non-sporting patients demonstrated improvement in self-reported function, sporting patients reported higher function levels and 4x the odds of perceiving a meaningful overall improvement in function 2-years post-operative. Regardless of group, the majority of patients felt surgery met their expectations. While all patients experienced benefits of cartilage repair/restoration, these benefits may be enhanced by the physical and mental demands of sports participation prior to injury. Non-sporting patients may need to be counseled that their results may be lower than sporting patients. Further research may be needed to determine if pre-operative activity increase may lead to better overall results at 2-years.

History of Major Lower Extremity Injury Associated With Subsequent Injury in Collegiate Club Sport Athletes

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Context: Previous injury is a risk factor for sustaining subsequent injuries. However, it is unknown if the severity of the initial injury is associated with a greater number of subsequent non-contact injuries that may be preventable. **Objective:** To determine if history of major lower extremity (LE) injury is associated with subsequent non-contact LE injury occurrence. A positive correlation between major LE injury history and frequency of subsequent non-contact LE injuries was hypothesized. **Design:** Cross-sectional study. **Setting:** Biomechanics Laboratory. **Patients or Other Participants:** Collegiate club rugby and ultimate frisbee athletes (n = 34; 18 female [12 rugby, 6 ultimate], 16 male [8 rugby, 8 ultimate]; age = 20.8 ± 1.7 yrs; height = 171.5 ± 8.6 cm, mass = 72.9 ± 14.7 kg). **Interventions:** Participants underwent pre-season screening. Major LE injury was defined as a self-reported fracture, dislocation/subluxation, or sprain for which medical attention was sought from any healthcare provider since freshman year of high school and resulted in ≥3 weeks of lost time. Participants completed weekly online surveys to self-report physical activity and injuries occurring the previous week during team practices and competitions. Concussions, contusions/abrasions, and injuries resulting from contact or unorganized events were excluded. **Main Outcome Measures:** Point-biserial correlation was used to determine the association between previous major LE injury and subsequent non-contact LE injuries during one competitive season ($\alpha = 0.05$). Injury frequencies were rank ordered and a Mann-Whitney U Test was used to determine if groups with and without previous major LE injury differed in frequency of subsequent LE injuries incurred during one competitive season ($\alpha = 0.05$). **Results:** Of the 34 participants, 16 (47%) reported previous major LE injury and 18 (53%) reported sustaining at least one non-contact LE injury during the competitive season. Commonly reported non-contact LE injuries were 6 (30%) ankle sprains, 3 (15%) knee sprains, and 3 (15%) thigh musculature strains. Previous major LE injury was significantly correlated with the frequency of subsequent LE injuries during a competitive season ($r_{pb} = 0.35$, $r_{pb}^2 = 0.12$, $p = 0.04$). Those with a history of major LE injury did not have significantly greater subsequent LE injury frequency than those without (1.4 ± 1.0 vs 1.0 ± 0.8; $U = 91.0$, $z = -2.0$, $p = 0.05$, $d = 0.6$, power $(1-\beta) = 0.7$). **Conclusions:** Self-reported major LE injury resulting in ≥3 weeks of time loss occurring within a previous 5-8 year time period was moderately correlated with the frequency of subsequent LE injuries during one competitive season in club sport athletes. There was not a significant difference in frequency of subsequent LE injuries based on history of major LE injury. A collegiate club sport population appears to suffer major injuries prior to participating in the collegiate level, that are then moderately associated with a greater frequency of subsequent LE injuries. Injury prevention intervention strategies may be warranted in this population, who may lack access to sports medicine care.

College Baseball Pitchers Have Increased Glenohumeral External Rotation and Total-Arc Range of Motion Compared to Non-Pitchers

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Context: Collegiate baseball players spend time engaged in overhead throwing activities for several months during the year. Stress on the shoulder may be different dependent on player positions. This stress may be reflected in differences in shoulder range of motion and provide healthcare providers with better insight into the demands of the sport. In addition, this stress and associated adaptations may be influenced by the length of time players began their playing career. **Objective:** To determine differences in shoulder rotational range of motion (ROM) between pitchers and non-pitchers, and to investigate how time spent participating in baseball influences ROM in these athletes. **Design:** Cross-sectional. **Setting:** Athletic training facility. **Patients or Other Participants:** Fifty-five healthy, NCAA D-1 baseball athletes participated in the study and were divided into two groups based on their current position on the team. Pitchers (N = 32, age = 20.56 ± 1.34 years; height = 187.4 ± 6.54 cm; mass = 87.17 ± 7.26 kg) only participated as pitchers, while non-pitchers (N = 23, age = 20.35 ± 1.55 years; height = 184.86 ± 4.59; mass = 87.86 ± 6.50 kg) played any other position other than pitcher. **Interventions:** Dominant (DOM) and non-dominant (NDOM) shoulder passive ROM was assessed using a digital inclinometer by a single investigator. Data related to previous athletic activity was gathered via questionnaires given to each participant. **Main Outcome Measures:** Shoulder internal (IR) and external (ER) ROM were measured three times, and the average calculated for data analysis. IR, ER and total arc ROM from the DOM and NDOM shoulders, the difference between DOM and NDOM total arc ROM (TAD) and the demographic data

were analyzed using one-way ANOVAs (a£ .05). **Results:** Pitchers demonstrated significantly greater dominant ER ROM (143.88 ± 16.92°) and DOM total arc ROM (204.25 ± 22.88°) compared to non-pitchers (ER: 135.85 ± 9.87°, $F_{1,53}$ = 4.152, P = 0.047; Total Arc: 192.40 ± 16.09°, $F_{1,53}$ = 4.54, P = 0.038). No significant differences were found comparing DOM IR (Pitcher = 60.37 ± 13.62°, Non-Pitcher = 56.56 ± 10.52°, P = 0.266), NDOM ER (Pitcher = 125.55 ± 13.63°, Non-Pitcher = 122.39 ± 12.07°, P = 0.378), NDOM IR (Pitcher = 66.09 ± 12.46°, Non-Pitcher = 63.30 ± 10.00°, P = 0.379), or NDOM total arc (Pitcher = 191.64 ± 19.83°, Non-pitcher = 185.69 ± 14.51°, P = 0.227). The pitchers (18.5 ± 15.7) had significantly greater disparity between TAD compared to non-pitchers (10.5 ± 8.5, $F_{1,53}$ = 4.784, P = 0.033). Additionally, pitchers (8.34 ± 2.13 years) reported beginning baseball at an older age than non-pitchers (6.70 ± 2.49 years) ($F_{1,53}$ = 6.93, P = 0.011). **Conclusions:** Pitchers demonstrated significantly greater DOM arm ROM compared to non-pitchers and a larger disparity between DOM and NDOM total arc ROM. The study supports prior research that ROM adaptations are not necessarily pathologic, and may actually be important for performance based on a player's position. However, non-pitchers reported beginning their baseball careers almost 2 years earlier compared to pitchers. This may indicate that length of time participating in baseball may have less influence on ROM adaptations than throwing volume and generated forces at the glenohumeral joint, which are both greater in pitchers. Clinicians can use this data to better understand the specific ROM changes observed in healthy collegiate baseball pitchers and non-pitchers.

Master's Poster Award Finalist

The Epidemiology of Overuse Conditions in Youth Football and High School Football

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Context: Over 60 million athletes aged 5-18 years old participated in organized athletics. High intensity sports training at the youth level has increased concern of overuse conditions, but limited research exists on this topic. **Objective:** To examine the rates, risks, and distributions of overuse conditions between youth and high school football. **Design:** Descriptive epidemiologic study. **Setting:** Youth football and high school football teams. **Patients or Other Participants:** The Youth Football Safety Study (YFSS) included more than 3000 football athletes' ages 5-14 years old from 13 youth football leagues and 6 states, encompassing 210 team-seasons. The National Athletic Treatment, Injury, and Outcomes Network (NATION) consisted of high school football athletes' ages 14-18 years old from 96 secondary school football programs; during the 2012 and 2013 football seasons, NATION collected data during 138 team-seasons. **Interventions:** Athletic Trainers reported injuries and athlete-exposures. **Main Outcome Measures:** Athletic trainers collected football injury and exposure data during the study period. Injury rates per 10,000 athlete exposures (AE), risks, and distributions were calculated. Injury rate ratios (IRR), risk ratios (RR), and injury proportion ratios (IPR) with 95% confidence intervals (CI) were used to compare high school and youth football. For an injury to be included in the analysis an overuse condition were injuries with the injury mechanism recorded as "overuse/gradual onset". However, to include overuse conditions that may have been missed due to this inclusion criteria, we also included those injuries recorded as being chronic in nature. Injuries were categorized as non-time loss (NTL) injuries (resulting in participation restriction time under 24 hours) or time-loss (TL) injuries (resulting in participation restriction time of at least 24 hours). **Results:** YFSS reported 1488 injuries, of which 53 (3.6%) were overuse conditions. NATION reported 12,013 injuries, of which 339 (2.8%) were overuse conditions. The overuse condition rate did not differ between high school and youth football (3.93 vs. 3.72/10,000AE; IRR = 1.06; 95% CI: 0.79-1.41). However, the one-season risk of overuse condition was greater in high school than youth football (2.66% vs. 1.05%; RR = 2.53; 95% CI: 1.84-3.47) because the proportion of athletes that suffered more than one overuse condition was higher in youth (10/53; 19%) than high school athletes (21/339; 6%). Compared to high school football, youth football had greater proportions of overuse conditions that were NTL (83.0% vs. 67.0%; IPR = 1.24; 95% CI: 1.07-1.43) and at the lower extremity (92.5% vs. 62.5%; IPR = 1.48; 95% CI: 1.32-1.65). **Conclusions:** Overuse conditions may not present a primary concern in youth and high school football. However, differences existed between the two levels of competition. Although additional research on the incidence of overuse conditions across all youth and high school sports is needed, these findings highlight the need for programming that may be specific to competition level.

Effectiveness of Pre-Participation Physical Exams in Screening for Mental Health Disorders in Secondary School Athletes

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Context: Mental and physical health are both crucial components of the athletic trainers' role in injury prevention and management. These two conditions often impact one another with physical injury having psychological or emotional consequences and psychological problems, including disordered eating and substance abuse, having physical consequences. Like physical injuries, mental health disorders may limit or preclude athletic participation until the condition has been adequately identified and treated. **Objective:** The objective of this study was to examine the effectiveness of each state high school athletic association's (SHSAA) recommended or required PPE form for screening for Mental Health Disorders. Several sources, including guidelines from the American Academy of Family Physicians, sports psychology textbooks and the PHQ-9 Health Patient Questionnaire, were utilized to identify seven recommended areas for mental health screening in patients. **Design:** This study used an enumeration design to examine each SHSAA's recommended or required PPE form for effectiveness in screening for Mental Health Disorders as measured by assessing questions in seven content areas. **Setting:** The study was conducted in a University research laboratory. **Patients or Other Participants:** Each SHSAA served as a subject in this study. **Interventions:** Each SHSAA's PPE form was utilized to examine effectiveness in screening for Mental Health Disorders based on expert recommendations as identified in the available literature. These forms were accessed from the association's website or by contacting the organization if the forms were not available via the world-wide web. **Main Outcome Measures:** Each content area was scored as either assessed or not assessed and one point was awarded for each area that was assessed, for a maximum score of 7. **Results:** 48 of 50 (96%) of SHSAA utilize a recommended or required PPE form. Of these, 20/48 (42%) utilize the American Academy of Family Physicians (AAFP) PPE form in its entirety, 3/48 (6%) use an abbreviated version of the AAFP PPE form and 25/48 (52%) utilized a form developed by the SHSAA. Mean score was 2.35/7 (range 0-4) and median score was 2/7 for Mental Health Disorder screening effectiveness. 22/48 (46%) state associations scored 4 points for screening, while 12/48 (25%) state associations scored 1 point and another 8/48 (17%) scored 0 points for screening. The most commonly screened areas included depression (48%), stress (56%), disordered eating (83%), and substance abuse (46%). Three areas that failed to be screened by any state association's PPE form included sleep disturbances, feelings of disappointment for letting others down, and causing physical harm to oneself. **Conclusions:** SHSAA are not doing an adequate job screening for Mental Health Disorders in athletes during PPE. States utilizing the AAFP PPE form score the highest, assessing four of the recommended seven content areas for Mental Health screening.

UCL Sprain With Associated Radial Head Fracture in a Collegiate Softball Player

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Background: A 20-year-old female softball player/pitcher fell on outstretch hand (FOOSH) in shoulder extension in the dugout February 2016. She felt immediate pain at medial elbow along with a sensation of a pop in her pitching arm. She had no history of injury or pain in the area. She experienced pain at the forearm over the flexor muscles and was point tender over UCL and radial head. The athletic trainer preformed the initial evaluation and found AROM and PROM to be painful with elbow flexion and extension along with limited ROM in extension and MMT consisted of 3/5 wrist flexion, 4/5 wrist extension, 3/5 elbow flexion and 3/5 elbow extension. Athlete tested positive for valgus stress test and negative for milking test and Tinel's sign. The athletic trainer's assessment was UCL sprain along with flexor strain. Four days later, the athlete saw an orthopedic surgeon for further evaluation and X-rays resulting in a diagnosis of grade 1 UCL sprain, flexor strain, and radial head fracture confirmed by subsequent MRI, one day later. **Differential Diagnosis:** elbow dislocation, collateral ligament, radial head fracture, radiocapitellar chondromalacia, osteophyte, posterior interosseous or median neuropathy, posterolateral instability. **Treatment:** Both restoration of the ulnohumeral joint and elbow stability can be reestablished without surgery in nondisplaced radial head fractures, therefore surgery was not warranted for this patient. Physician instructed athlete to wear a hinged adjustable brace and told to rest as needed. Immediate treatment involved cryotherapy and flexor/extensor stretching of wrist and elbow. At 12 days post-injury, athlete was cleared for pitching but not hitting and was allowed to remove brace (due to functional limitations) for practices and games. Athlete regained full flexion with a deficit of 10 degrees of extension one month post-injury. Athlete was instructed to avoid any collision or contact with other players in an attempt to avoid re-injury. The rehabilitation program included joint mobilization focused on regaining elbow extension. Wrist and elbow strengthening was initiated at one month to correlate with UCL healing time with continuation of stretching, ice, and NSAIDs as needed. At 2 months post injury athlete was given full return to play including hitting with only a 3 degree extension deficit. Athlete was encouraged to avoid collisions with other athletes that might put undue force on the elbow. **Uniqueness:** UCL injuries in conjunction with radial head fractures are an uncommon combination especially at the low velocity mechanism of injury displayed in this case. **Conclusions:** The athlete experienced an unusually fast recovery with better than average return to pitching results with little to no pain. It is not uncommon for patients with radial head fractures to experience ROM deficiencies when casted, therefore not casting seems to promote early ROM and function. This athlete's return to play was faster than anticipated according to normal RTP, as she was able to pitch in 2 innings 12 days after her injury and was cleared for full pitching by 1 month. Two months post injury athlete was fully cleared for hitting and all other sports specific activities. Due to biomechanics of softball, it should be noted that players could be partially returned to play based on physical demands needed for each athletic skill. Although, this case resulted in positive performance at an early stage without complications, each clinician should evaluate whether patient re-injury risk outweighs the benefits of early return. Additionally, upon initial evaluation the torsion component of the mechanism was not taken into consideration and therefore the radial head fracture was overlooked as a possible injury resulting in lack of splinting. This case study is a reminder to health care professionals to always evaluate surrounding structures.

Unilateral Rhabdomyolysis of the Forearm in a Collegiate Tennis Player: A Case Study

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Background: A 22-year-old collegiate female tennis player presented to the athletic training clinic with pain and swelling in the right forearm following playing four matches the previous day. The patient reported a history of shoulder tendinopathy and heat exhaustion, but no significant injuries or conditions that had affected her forearm up thus far. **Differential Diagnosis:** Forearm Cramps, Exertional Compartment Syndrome, Exertional Thrombosis, Flexor Mass Tendinopathy, Thoracic Outlet Syndrome. **Treatment:** Day 1, the patient presented to the athletic training clinic having increased swelling in right forearm and noticeable swelling in right hand along with increased pain and loss of grip strength. Patient was held out of participation and prescribed ice and ibuprofen for pain and an ace bandage to reduce swelling. The patient reported that compression increased the pain and increased swelling in the digits, leading to the discontinuation of bandaging. Day 2, the patient reported that swelling and pain were still noticeable but had decreased. The patient disregarded recommendations by medical personell to limit participation. Symptoms returned halfway through the patient's first match and the patient retired. The patient was then scheduled to see team the physician, as symptoms had not improved. Day 6, the patient was seen by the team physician for further evaluation. During exam, patient reported mild swelling in right forearm and right upper arm with tenderness in wrist extensors. Girth measurements on right forearm were 2 cm larger than the contralateral forearm. The patient reported urine color as a dark yellow-orange. The team physician diagnosed patient with localized exertional

rhabdomyolysis. The patient was instructed to improve hydration, ice, maintain complete rest and to present with no pain or swelling before beginning a gradual progression to regular activities. Day 9, despite recommendations, the patient played tennis. The patient reported light pain and swelling and ceased participation. Day 13, the patient was seen again by team physician for a follow up evaluation. Girth measurement of right forearm was still 1.5 cm larger than the left, which was attributed to swelling and hand dominance. The patient reported return of tenderness and discomfort with resisted extension. The patient was instructed to begin a strict progression to return to participation and the program would not progress if forearm swelling and tenderness were present. Day 14, the patient began the first phase of her return to play protocol. Day 20, the patient had a follow up evaluation with the team physician. The patient reported no pain, forearm tenderness, and swelling. Girth measurements showed the right forearm to be 1 cm larger than the left, and the patient demonstrated full strength without pain. Day 21, the patient progressed to light tennis with no recurrence of symptoms. Day 24, the patient progressed full speed tennis has no recurrence of symptoms. **Uniqueness:** Rhabdomyolysis typically occurs in more than one body part. In the reviewed literature, any cases of rhabdomyolysis involving the forearm involved subsequent presentation in other muscle groups of the upper extremity, or the bilateral forearm. This patient likely experienced unilateral rhabdomyolysis of the forearm extensors due to the nature of her sport and training regimen. **Conclusions:** A thorough and comprehensive evaluation is paramount when beginning a treatment course for patients. An understanding of the signs and symptoms of different injuries and conditions can expedite the evaluation process, and allow appropriate care to begin sooner. Athletic trainers must constantly strive to improve trust from patients to ensure compliance, as this is crucial for the proper management and treatment of nearly every musculoskeletal condition that will be encountered.

Posteriorly Displaced Mid-Body Scapular Fracture in a Football Player

Allas LM, Matrisciano MC, Siple BJ, Burnett J: Slippery Rock University of Pennsylvania, Slippery Rock, PA; Karn City High School District, Karn City, PA

Background: The objective of this case study is to provide information on a scapular fracture. The patient is a seventeen-year-old, white, male, football player at the wide receiver position. The patient's previous medical history consists of a partial labral tear of the left shoulder and an ipsilateral scapular contusion earlier in the season. No other medical history was relevant to this injury. The scapular fracture occurred during a football game when the patient was tackled between two opposing players and forced to the ground. Upon initial evaluation, the player presented with a significant amount of edema surrounding the left posterior shoulder and reduced range of motion. No obvious gross deformity or ecchymosis was evident. The patient stated that the pain "felt different" when compared to his previous labral tear. Palpation of the shoulder was limited due to the patient's point tenderness. The patient was treated for a possible contusion and instructed to follow-up. Further evaluation was performed the Monday after the injury occurred. The patient presented with a minimal reduction of edema and pain. Shoulder range of motion remained inhibited due to discomfort. The athletic trainer referred the patient to a physician for evaluation and diagnostic imaging. Radiographs and computerized tomography scans revealed a minimally displaced fracture of the body of the left scapula. **Differential Diagnosis:** Initially, the patient was suspected to have suffered a contusion of the scapula. Other viable pathologies were a labral tear, especially given the patient's history of a partial labral tear to the ipsilateral shoulder. Other possible injuries included a humeral head subluxation, and a rotator cuff strain or tear. **Treatment:** No surgical intervention was indicated. Surgical intervention is not usually required or recommended for fractures of the scapular body unless it is exceptionally displaced. Through conservative treatment, such as cryotherapy and immobilization, followed by range of motion and strength exercises, the patient met the required criteria of normal range of motion, strength, and function to return to play. **Uniqueness:** Scapular fractures are unique to traumatic experiences, such as motor vehicle accidents, due to the high impact mechanism. Accordingly, they only account for less than 1% of all fractures. **Conclusions:** Scapular fractures in the athletic setting are extremely rare due to the high impact mechanism of injury. Non-displaced scapular fractures may present with clinical similarity to a contusion or a labral pathology.

Conservative and Surgical Treatment of an Acute Traumatic Extensor Carpi Ulnaris Tendon Subluxation in a Collegiate Tennis Player: A Case Report

Werner JL, Nakamura Y, Lawton J: University of Michigan Athletic Medicine, Ann Arbor, MI; University of Michigan, Department of Orthopaedic Surgery, Ann Arbor, MI

Background: 20-year old female NCAA D1 collegiate tennis player presented with acute traumatic left ulnar-sided wrist pain, onset felt with a 'large crack' during a double-handed backhand (BH) in match play, July 2014. Chief Complaint: pain with pronation and ulnar deviation. No previous history of wrist injuries. Physical examination revealed localized pain and crepitus over dorsal ulnar aspect of wrist joint with pain on palpation of the ECU tendon. **Differential Diagnosis:** Triangular fibrocartilage complex tear, wrist extensor tendinopathy, ulnar stress fracture. **Treatment:** Patient was examined by Certified Athletic Trainer (YN) and referred to a hand specialist (JL). X-ray negative for fracture. Upon active forearm rotation, the ECU tendon subluxated over the ulnar head. Physician diagnosed as ECU subluxation and placed patient into a Muenster Cast, above elbow, in supination and 10 degrees ulnar deviation for 6-weeks. During immobilization, the patient was able to participate in tennis activities without BH; toss for serves initiated around 3-weeks. After 6-weeks, patient was placed into a removable Orthoplast Muenster Splint. Upon examination, the ECU was stable through rotation although having moderate levels of pain with movement due to ECU tendonitis. Periodic brace removal was allowed to initiate only active wrist and elbow range of motion (ROM) and lumbrical exercises 3-5 times daily. Within one week, 45-degrees of pronation was regained and pain levels decreased. After 3-weeks, progressed to wrist and elbow strengthening, movement without impact. Full active ROM and normal carrying angle were achieved, especially pain-free pronation, then began strengthening. Mid-September, 8-week progression of BH began with low repetitions with foam ball, to half court distance with decompressed ball, to finally full court with regular 2.0-oz tennis ball. Stiffness and soreness through motion were typically reported but no instability was indicated. Began to hit BH full go by mid-November. Overload volume over 4-weeks produced reproduced ECU instability and increased pain. Patient was rested from BH, returned to brace and received steroid injection at site of ECU to allow comfort with tennis. Moderate pain and movement of ECU tendon provided stress and frustration for patient. However was able to complete full NCAA collegiate season with limited to BH in match play only, immobilized at rest, and routine soft tissue treatment of associated structure. Tape or bracing was unsuccessful at minimizing ECU subluxation. May 2015 surgery was recommended for ECU Sheath Reconstruction (JL). With season completion, patient underwent surgery and immobilized in Muenster Cast for 6-weeks, then removable brace for 6-weeks. Scar and soft tissue mobilization were indicated immediately post immobilization. Manual overpressure in pronation and supination were started around 4-weeks post-operatively. At 3-months post-op, the athlete began hitting BH and began a return-to-hitting progression. At 4-months the athlete had been cleared for full participation. **Uniqueness:** ECU tendon subluxation may be more common than expected if misdiagnosed. Collaboration between hand surgeon and ATs allowed for year-long conservative management of ECU subluxation ensuring minimal time-loss for collegiate tennis player. Post-collegiate career, surgical intervention for this case has allowed full healing and this athlete has been competing successfully playing on the professional tennis circuit without recurrence for 1-year. **Conclusions:** Ulnar-sided wrist pain with accurate examination by the clinician is essential for diagnosis of ECU tendon disorders. Early diagnosis and conservative management allowed for minimal time-loss during NCAA D1 Tennis Season. Post-operative compliance and teamwork of physician, patient, and AT can result in better than expected outcomes. The athlete has now returned to full competition with no wrist pain and is playing on the professional tennis circuit.

Distal Humeral Fracture and Radial Nerve Palsy in a High School Football Player

Cox CE, Kunkel LE: Texas Wesleyan University, Fort Worth, TX

Background: A 17-year-old high school football player presented with initial complaints of pain in his left elbow. The patient stated that he was blocking another player, but could not explain exactly what happened. Video footage showed his shoulder abducted and his elbow flexed to 90 degrees as he went in for a block. The initial evaluation showed severe instability in his elbow. Bump and squeeze tests were both negative and no other tests were performed due to apparent gross instability. No neurological symptoms or previous medical history were reported. **Differential Diagnosis:** Elbow dislocation, humeral fracture, ulnar fracture, radial fracture, radial head fracture **Treatment:** The patient was placed in a sling with an ice pack and sent to the emergency department. Radiographs showed a displaced distal humeral fracture. The patient stated that when the radiology technician placed his arm in the needed position for the X-ray, he felt excruciating pain. This movement may have caused the displacement. Following the radiographs, he complained of decreased sensation on the dorsal side of his hand and thumb and was unable to extend his thumb. The patient was diagnosed with radial nerve palsy, thought to be caused by displacement of the fracture. Surgery was performed to repair the humerus with a plate and 9 screws. The patient was instructed to wear a sling and brace to keep the wrist in extension and take pressure off the radial nerve. Post-surgery rehabilitation started almost immediately and primarily consisted of passive and active elbow extension exercises and active thumb extension with biphasic electrical stimulation. Approximately two months post-surgery, the patient is continuing much of the same rehabilitation exercises. Normal elbow extension has been achieved and the patient has regained a mild amount of sensation in his hand.

Uniqueness: The fracture may have been non-displaced prior to being positioned for radiographs. Therefore, surgery and neurological impairment may have been avoided had a fracture been detected beforehand. Fractures are common, however those that include radial nerve palsy are not. **Conclusions:** Presented was a 17-year-old high school football player with a distal humeral fracture who later developed neurological symptoms. It is important for healthcare professionals to understand that even with appropriate immediate care, additional complications may develop.

Nerve Pain Following Surgical Procedures in College Bowling Athlete

Mullins-Zugelder K, Felton SD, Craddock JC, Desmarteau T: Florida Gulf Coast University, Fort Myers, FL; Webber International University, Babson Park, FL

Background: Athlete is a 19 year-old male NAIA bowling athlete. Athlete weighed 74.8 kg and is 165 cm tall. Athlete's prior medical history included medial epicondylitis in the right arm, which lead to ulnar nerve pain in the same arm. Athlete was diagnosed with ulnar nerve entrapment. Pain and numbness originated in the elbow and then traveled to the hand. Ulnar nerve transposition surgery was subsequently required two months later. Following the surgery, rehabilitation and treatment was attempted until pain and numbness occurred again. Pain was localized to the wrist and was substantiated when diagnosed with median nerve entrapment. Pain originated in the distal aspects of the fingertips and then traveled to the medial epicondyle of the elbow. Surgical median nerve release was required to increase the size of the carpal tunnel and decrease the pressure placed on the median nerve. The transverse carpal ligament was released. Complete release was taken both distally as well as proximally with release of forearm fascia. Scar tissue found around the median nerve was removed during surgery as well. Following the surgery, pain and numbness continued along the ulnar and median nerves, but also followed into the radial nerve along the extensor musculature. Athlete had been withheld form athletic activity for entire year, since symptoms first began. Full active range of motion (AROM) and strength with wrist flexion and extension, but pain noted for both. **Differential Diagnosis:** Radial Nerve Entrapment, Radial Nerve Palsy Median Nerve Entrapment, Ulnar Nerve Entrapment, Medial Epicondylitis. **Treatment:** Athlete commenced conservative treatment with athletic training staff for three weeks, but no relief was noted. Treatment included rest, ice along the wrist and forearm of the involved arm, and massage for treatment of pain. Pain was still immense throughout daily activities. Treatment only momentarily reduced pain. Rehabilitation was not possible due to immense pain caused by the injury. Athlete had been referred to physician for further evaluation. **Uniqueness:** Medial epicondylitis is a common injury among bowling athletes due to the mechanism of forcefully grasping the ball and flexing the wrist when releasing the ball. Ulnar neuropathy has been associated with medial epicondylitis in 50% of cases. However, the transmission of pain to the median and radial nerves is not commonly seen, especially with such a severe reduction of activity. The prognosis of continual pain and numbness despite two separate surgeries, followed by consistent conservative treatment, is a unique situation that suggested the use of the kinetic chain in the hand, wrist, forearm, and elbow. **Conclusions:** This case highlighted the diagnosis and treatment of a bowling athlete suffering from ulnar, median, and radial neuropathies despite having an ulnar transposition surgery and median nerve release surgery. This case further highlighted the symptoms from these separate injuries and the different types of treatment utilized. This case report demonstrated the correlation of the different aspects of the hand, wrist, forearm, and elbow and how different biomechanics and motions can affect the nerve pathways. This case report examined the complexities of the human anatomy and the importance of having early interventions for medial epicondylitis, as well as other hand, wrist, forearm, and elbow injuries. This case further suggested the correlation of nerve pathologies and connected musculature and the effects of surgical treatments.

Conservative Treatment of a Posterior Labrum Tear in a College Football Athlete

Brooks MR, Felton SD, Craddock JC: Florida Gulf Coast University, Fort Myers, FL

Background: The athlete was an 18-yo freshman college football defensive lineman, 187.9cm and 86.2kg. He reported with no prior medical history or injuries. Athlete suffered a posterior shoulder dislocation to his left arm during the first scrimmage of preseason training when a lineman fell on top of his outstretched arm. The dislocation was reduced by the team athletic trainer and he was unable to play for the duration of the scrimmage. The next day he practiced as tolerated in a shoulder brace during the and reported slight pain. However, the following day his pain had increased substantially. The athlete had no obvious deformities, no discoloration, and slight swelling on the posterior aspect of his shoulder. His active range of motion (AROM) had decreased and was measured as follows: forward flexion 42 deg, abduction 90 deg, extension 55 deg, external rotation 70 deg, internal rotation 24 deg. The majority of his pain occurred with flexion and internal rotation. The athlete complained of sharp pain in the back of his shoulder and feeling as if his shoulder was unstable. Due to his lack of motion his strength was not tested. Orthopedic clinical examination included O'Brien's and posterior apprehension test, which were both positive. **Differential Diagnosis:** Posterior labrum tear, Posterior shoulder instability, Supraspinatus strain, Posterior deltoid strain. **Treatment:** As a result of the athlete suffering from a complete shoulder dislocation and his demonstrated loss of AROM he was referred to the team physician and an MRI was ordered. The MRI revealed a posterior labrum tear. The athlete in consultation with the physician elected against surgery performed until end of the season. He was treated conservatively with pain modulation, ROM exercises, and strengthening of the shoulder stabilizing muscles, specifically the rotator cuff and scapular stabilizers. After 3 weeks of rehabilitation he returned to participation and his initial injury was reaggravated and he could not continue to play. Conservative treatment was resumed to decrease pain and increase ROM and surgery was decided to be in the best interest of the athlete to allow the athlete to return to the previous level of sports participation. **Uniqueness:** Posterior labrum tears are rare, but when they occur in sports will be seen mostly in contact/collision sport athletes. These athletes engage opponents with arms in front of their body causing them to become susceptible to posterior labrum tears. He opted to not have surgery and initiate a conservative treatment to return to play before the season ended. After three weeks he had regained his motion and strength and felt he could start practicing again. The athlete aggravated his injury and felt he could not play without undergoing surgical repair. Conservative treatment was resumed to reduce the athletes pain, restore full motion, and regain his strength. Research has demonstrated improvements with SLAP tears when treated non-surgically and this case allows posterior labrum tears to be evaluated for the improvements made using conservative treatment rather than surgical repair. **Conclusions:** This case explored the conservative treatment of an uncommon labrum tear and the possibility of returning to sports without surgery. In this case the conservative treatment was effective in decreasing pain and restoring the athlete's range of motion and strength. However, the return to the sport that caused the injury caused the injury to become further aggravated due to the nature of the sport. In contact sports it seems unlikely that a return to sports without surgery will be an effective form of treatment without causing further irritation to the injury.

Latissimus Dorsi Tear With Surgical Repair in a Professional Baseball Pitcher: A Case Report

Skipper ES, Lumpkin KJ: Lee University, Cleveland, TN

Background: A 24 year old professional baseball pitcher was taken out of a game after complaints of pain and cramping behind his right axilla. The athlete stated that he felt like his arm had "locked up" and by the third batter he was not able to make a pitch to the plate. His pain was strongest when he reached the point of full extension during the acceleration phase of pitching. Upon initial examination he had 4/5 latissimus dorsi strength and limited shoulder flexion and abduction. He had no previous right shoulder injury. **Differential Diagnosis:** Teres minor strain, latissimus dorsi strain **Treatment:** The following day an x-ray and magnetic resonance image (MRI) were taken. The x-ray came back negative of any pathology, but the MRI showed a high grade 2 strain of the latissimus dorsi at the point of attachment. A few days later he received a platelet-rich plasma (PRP) injection in his axilla in hopes of promoting healing, however, this did not lead to any significant improvement. For three and a half months the athlete underwent a conservative rehabilitation program that focused on rotator cuff strengthening and scapular stabilization within the pain free range of motion followed by a progressive throwing program. He began pitching again after the three and a half months of consevative treatment, but after 4 games he was no longer able to make his pitches reach the plate. He took himself out of the game complaining again of tightness and cramping his right axilla, with the addition of tightness and cramping in his triceps muscle group. He received another MRI which showed a 50% tear of the latissimus dorsi and a 1+ triceps strain. His options were to continue with conservative treatment or have surgery. He opted to have surgery where the surgeon discovered a 60% tear of the latissimus dorsi

along with scar tissue formation that extended to the triceps brachii. Following surgery the athlete was immobilized in a sling for six weeks and began rehabilitation. For seven months he progressed through rehab and a throwing program until he returned to play. He did return to pitching in the major league, however his velocity had decreased and he retired the following year. **Uniqueness:** An isolated latissimus dorsi tear is uncommon, and it is even more uncommon for it to be treated surgically as it was in the case of this athlete. Because a decrease in strength in the latissimus dorsi does not have a huge effect in function of the average person, surgical intervention is not likely to be used in the normal population. Even in the elite population, three months of conservative treatment has shown to be the most common successful treatment of a latissimus dorsi tear. Therefore, limited research is available on surgery and rehabilitation following a latissimus dorsi surgical repair, making it questionable even in elite athletes. **Conclusions:** Because latissimus dorsi tears are uncommon, Athletic Trainers should be aware of the signs and symptoms associated with this injury, and an individual approach should be taken with each case. This case reveals possible complications and treatment options for a latissimus dorsi injury when conservative treatment is not successful.

Cervical Spinal Stenosis Presenting as Shoulder Pain and Upper Extremity Paresthesia in an Adolescent Athlete

Gay EM, Butterfield TA, Uhl TL: University of Kentucky, Lexington, KY

Background: In July 2016, a 13-year-old volleyball athlete presented with right anterior shoulder pain and paresthesia in the fourth and fifth digits and medial forearm. She stated that symptoms began in October 2015, when she felt a pop and immediate pain in her right shoulder during a serve in middle school volleyball practice. She was taken to the emergency room, where radiographs were negative, and she was instructed to rest for two weeks. She returned to volleyball with continued shoulder soreness. Within two weeks of return to play (RTP), paresthesia developed in her forearm and hand, for which she did not seek medical attention. The patient reported to the high school athletic trainer (AT) in July 2016, during offseason practice, complaining of worsening paresthesia that had moved proximally into the medial arm. Observation revealed no obvious deformity, atrophy or dissymmetry of the shoulder. She was point tender over the right upper trapezius, long head of the biceps tendon, scalenes, sternoclavicular head of pectoralis major and proximal latissimus dorsi. Dermatome testing identified sensory alteration in the C8, T1 dermatomes of the right side. Myotomes, radial pulse, and capillary refill were within normal limits. Shoulder ROM was full in all planes, but symptoms intensified with end range of passive and active shoulder flexion and horizontal abduction. All tests for labral pathology or glenohumeral instability were negative. Allen's test, Roos test, and median nerve tension test were positive. Upon referral to a physician, radiographs were negative for presence of cervical rib. Magnetic resonance imaging with arthrogram (MRI-A) was negative for labral tear. Patient was prescribed 3 weeks of rest from volleyball with conservative treatment. Ulnar and median nerve flossing, completed daily with AT, provided temporary relief of paresthesia, but symptoms did not permanently resolve. Patient was returned to volleyball in August 2016 and encouraged to follow-up with neurologist. A second physician repeated imaging with identical results and again encouraged neurology referral. In September 2016, the patient suffered a grand mal seizure over the weekend outside of practice. **Differential Diagnosis:** Thoracic outlet syndrome, brachial plexus injury, ulnar nerve injury, labral tear, epilepsy, central sensitization. **Treatment:** Athlete was seen by a neurologist for electroencephalogram (EEG), MRI of the head and neck. EEG results were abnormal. MRI was negative for tumor, infection, etc. but coronal view showed right-sided narrowing of the intervertebral foramen of cervical vertebrae. Athlete was diagnosed with epilepsy and foraminal stenosis. She was placed on a low dose of Gabapentin and referred to physical therapy for cervical traction. **Uniqueness:** Cervical stenosis of the intervertebral foramen is usually associated with joint degeneration or osteophyte formation in the cervical spine, and is rarely symptomatic in adolescents. Prevalence is estimated using large radiographic studies that include asymptomatic patients, and stenosis of the spinal canal is most commonly evaluated, not foraminal stenosis. In epidemiologic studies of athletes, only football populations have been included. A search of "foraminal stenosis" AND adolescent AND prevalence produced two hits: 1. referencing 6th to 8th century AD skeletons; and 2. estimates of canal stenosis in football players, but not the foramen. Here, foraminal stenosis was not suspected until it was discovered during an unrelated examination of the head and neck following her first grand mal seizure. Finally, although evidence is limited regarding appropriate management and RTP of adolescent athletes with cervical stenosis, this patient achieved temporary relief with nerve flossing and cervical traction. **Conclusions:** Athletic trainers should not exclude evaluation of the neck in cases of upper extremity paresthesia, or rule out degenerative conditions in young athletes. Nerve flossing can provide transient relief for patients with highly irritable spinal stenosis.

Percutaneous Ultrasonic Tenotomy of the Common Extensor Tendon Origin

Skrobacki K, Felton SD, Craddock JC: Florida Gulf Coast University, Fort Myers, FL

Background: Patient is a 54 year-old (162.5cm and 53.9kg) female. The patient's activity level is low. She reported to the orthopedic clinic complaining of chronic pain on the lateral aspect of her right elbow that has lasted for 1 year in duration. The patient denied any specific mechanism. Initial evaluation revealed no obvious deformities, or signs of trauma. She was point tender over the lateral aspect of the epicondyle of the humerus and proximal forearm. Patient had full ROM, wrist flexion, extension, supination, pronation, radial deviation, and ulnar deviation. Limited strength of the right arm compared bilaterally, wrist extension 4/5, handgrip 4/5, and supination 4/5. Orthopedic clinical examination continued with the following: Tennis Elbow test (+), Mill's test (+), Varus stress test (-), Valgus stress test (-), Tinels sign (-), Pinch grip test (-). **Differential Diagnosis:** Lateral Epicondylitis, tendinopathy, tenosynovitis, tendinitis, syndesmosis, radial ulnar stress fracture, extensor carpi radialis (ECR) strain, and Extensor digitorum strain. **Treatment:** Patient began conservative treatment with prescription NSAID's, formal physical therapy, and home exercise program with no significant relief. Patient underwent evaluation with X-Ray and Ultrasound imaging. X-ray was normal, Musculoskeletal Ultrasound revealed hypoechoic area with signs of fluid accumulation and inflammation over the common extensor tendon origin. Patient underwent percutaneous ultrasonic tenotomy (Tenex, Tx1) as a treatment for lateral epicondylitis (Tennis Elbow). The Tx1 procedure is a sonographically guided percutaneous tenotomy and debridement technique that uses ultrasonic energy to produce low-amplitude, high frequency longitudinal oscillations of an 18-gauge hollow-tip needle. Following the Tenex procedure, the patient underwent 6 weeks of rehabilitation. Patient returned to ADL's without any complaints. **Uniqueness:** Lateral epicondylitis is a common injury in the general population. Research suggested that up to 3% of the population develops lateral epicondylitis lasting 12 to 24 months in duration. The average age to develop lateral epicondylitis is 35 to 55 years old. The most common mechanism is overuse. It has recently been seen less in tennis players possibly due to the lighter tennis rackets. This particular case report examined the recovery and outcome from percutaneous ultrasonic tenotomy of the common extensor tendon origin under local anesthesia following the unsuccessful use of conservative treatment. When compared to surgical procedures, Tenex is minimally invasive and has minimal to no operative risks. The Tenex recovery period is also shorter in duration. Studies would indicate that 95% of patients that received the Tenex treatment were satisfied and feeling better after the first week of recovery. **Conclusions:** This case study followed the outcome and recovery process of a patient that was diagnosed with lateral epicondilitis and tendinopathy. The study looks at the minimally invasive percutaneous ultrasonic tenotomy, Tenex, Tx1, procedures effectiveness and recovery rate. Conservative treatment failed making the patient a candidate for the procedure. After following up with the patient during the post procedure visits, the patient was experiencing satisfactory results with no complaints and sustained improvements. The patient returned to work under no restrictions after 4 weeks of light duty. As this procedure is becoming more popular and has shown to have more responsive results, athletes can look to this treatment when conservative treatment fails. When compared to surgical intervention, Tenex can be a faster road to recovery for athletes getting them back into their sport. Even though this procedure's outcome does correlate with other case studies, this study focused on one patient, so the outcome and results should be considered.

Non Ossifying Fibroma in a High School Athlete

Begley C: University of Kentucky, Lexington, KY; Paul Laurence Dunbar High School, Lexington, KY

Background: The athlete is a 14 year old male participating in football. The athlete's height is 67" and weighs 146 pounds. He has no reports no significant medical history. He reports to the Certified Athletic Trainer complaining of pain in his wrist and difficulty with motion secondary to a fall. **Differential Diagnosis:** Wrist Sprain, Ulnar Fracture, Radial Fracture. **Treatment:** The patient was assessed on in the Athletic Training Facility following the fall. Visual inspection showed no signs of obvious deformities, swelling, or ecchymosis. The patient was tender to palpation of the ulnar styloid process, radial styloid process, radial shaft, and carpal bones. Range of motion and manual muscle testing were not performed because of pain. Cryotherapy was performed by the ATC and a follow up examination was performed post treatment. Follow up examination was identical to initial evaluation. Distal radial pulse, sensory, and motor function was within normal limits. The ATC splinted the patient's wrist in position of function with SAM Splint and elastic bandage. The patient's pulse, sensory, and motor function was reassessed and found to be within normal limits. Patient was referred to orthopedist for evaluation. Radiographs were obtained and showed a buckle (torus) fracture of the distal radius as well as a non-ossifying fibroma lesion of the distal radial metaphyseal diaphyseal region. The lesion was determined not to need biopsy or follow up. Both injuries were treated non-operative in a short arm cast immobilization for four weeks. **Uniqueness:** In children, buckle fractures and non-ossifying fibroma lesions are common. However, for the athletic participation and history of this patient, it is unique he has not acquired an injury until now. These lesions are often found secondary to other injuries;

it is surprising he has no previous complications or injury. **Conclusions:** The patient was diagnosed with a buckle fracture and non-ossifying fibroma to the distal radius. The lesion was found secondary to the fracture and determined that no biopsy was needed. The patient was treated non-operatively and returned to ADL in four weeks. Athletic Trainers need to recognize and understand pediatric anatomy and conditions in the athletic setting for proper care and management.

A Unique Acromioclavicular Joint Separation in a Collegiate Basketball Player

Welch CA, Peak GM, Smith BI: The University of North Dakota, Grand Forks, ND; Lewis University, Romeoville, IL; The Pennsylvania State University, University Park, PA

Background: Background: A 19-year-old (170 cm, 80 kg) female collegiate basketball player with no prior history of shoulder pain injured her left shoulder after colliding with another athlete during competition. She immediately clutched her left arm and complained of pain on the anterior, superior, and lateral aspects of the involved shoulder. The athletic trainer examined her in this position and noted the scapula was protracted, no elevation of the clavicle relative to the acromion; however, there was an abnormal appearance of the AC joint. Upon palpation, there was a bony deformity over the AC joint but no fracture was suspected. There was no sternoclavicular tenderness or deformity noted. Radial pulse, capillary refill, and distal motor sensory function were normal and the athlete was placed in a sling. Ice and NSAIDs were used to manage the pain overnight and the athlete was referred to the team orthopedic physician the next day. **Differential Diagnosis:** Differential Diagnosis: Acromioclavicular joint sprain, sternoclavicular joint sprain, clavicle fracture, coracoid fracture. **Treatment:** Treatment: Radiographs revealed posterior displacement of the distal clavicle relative to the acromion, consistent with the rare type IV AC joint separation. Upon physician's examination, the patient had pain over the distal clavicle and AC joint consistent with the MOI involving a direct impact to the superior aspect of the left shoulder. There was a bony deformity at the AC joint and a sulcus deformity medial to the acromion. The patient had moderate effusion and reported pain a 9 out of 10 on the visual analog scale. The athlete reported an increase in pain with shoulder abduction. MRI showed no clavicular elevation relative to the acromion and tearing to both the AC and coracoclavicular ligaments. Based on the patient's pain and disability, she elected for surgical intervention and an open reduction of the left distal clavicle with an anatomical CC ligament reconstruction. The patient was placed in an external rotation sling at neutral following the procedure. Radiographs at one-month showed the surgery was a success with no loss of fixation. Rehabilitation began 5 weeks after the surgery to allow adequate tunnel healing. At 15 weeks post surgery, the athlete had full bilateral PROM, AROM, and strength in all planes of movement, along with functional activities. She was also able to perform overhead movements with moderate resistance and was discharged from formal rehabilitation and instructed to continue a home exercise program. At 4 months, the physician released the patient to full activity and she returned without any restrictions. **Uniqueness:** Uniqueness: Type IV AC joint separations account for less than 1% of all AC joint injuries in athletes. This case is especially unique because type IV sprains are not typically seen in female non-collision sports. Recovery will typically take up to six months to return to full participation but our patient was able to be back on the court in less than five months. This was in part due to the patient's young and healthy status, the type of procedure performed, and the fact that basketball has minimal overhead activity and is not a collision sport. **Conclusions:** Conclusion: Based on the MOI and the location of pain, the athletic trainer suspected an AC joint sprain. The athlete was referred to an orthopedic physician where the injury was confirmed by both radiographs and MRI. The type IV AC joint sprain is a rare injury and surgical intervention is often required for successful outcomes. When evaluating a potential AC joint sprain, it's important to rule out clavicle fracture and any possible neurovascular involvement. The athletic trainer may often see an SC joint sprain in combination with a type IV AC joint sprain.

Avulsed Upper Trapezius From Distal Clavicle in a Collegiate Football Player

Schmit KM, German NA: North Dakota State University, Fargo, ND

Background: A healthy 21-year-old Division 1 defensive lineman suffered an acute avulsion of the upper trapezius from the distal clavicle resulting from a direct hit by another player's shoulder pads. **Differential Diagnosis:** Acromioclavicular sprain, clavicle fracture, trapezius contusion, and trapezius strain. **Treatment:** During immediate on-the-field evaluation by the athletic trainer, palpation found a possible deformity on the distal clavicle. The athlete was placed in a sling and referred to the clinic for further evaluation. Radiographs were negative for bony involvement and the athlete was diagnosed with an acromioclavicular sprain. The athlete was treated conservatively for pain management. Ten days post injury, the athlete was still tender to palpate on the clavicle at the insertion of the trapezius. The athlete was re-evaluated by the team physician and was diagnosed with a trapezius injury and conservative treatment continued. Two weeks post injury an MRI was ordered on the shoulder. The results showed the acromioclavicular joint was unremarkable, but a small tear, 1.4 cm, of the trapezius on the distal clavicle was noted. Following this diagnosis the athlete began a rehabilitation program focusing on general strength and range of motion in affected shoulder. Four weeks post injury, based on physical examination, he was cleared by the team physician to begin a gradual return to play protocol. Athlete has since returned to full activity without further complications. **Uniqueness:** Currently, there is a lack of literature on trapezius avulsions in sport. The literature discusses trapezius avulsions from the thoracic spine that typically occur with heavy lifting. **Conclusions:** Trapezius avulsions are a rare occurrence in sport, whereas acromioclavicular sprains and muscle strains are commonly seen. A trapezius avulsion from the clavicle could be misdiagnosed as an acromioclavicular sprain or trapezius strain. It is important that the athletic trainer is able to recognize and differentiate between pathologies for appropriate treatment.

Enchondromatosis in the Hand of a Division I Lacrosse Athlete

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Background: A healthy 22 year-old male, NCAA D1 lacrosse athlete, presented with enchrondromatosis in his left upper extremity and a chief complaint of left thumb pain. The injury mechanism was described as a slash to the dorsal aspect of his left thumb while in flexion. Obvious deformities of his left thumb, index finger (IF) and ring finger (RF), discoloration and severe swelling of his thumb and severe abnormal growth and irregularity of his thumb nail were observed during physical examination. Due to a fused distal radio-ulnar joint, ROM was limited to 10-20° of supination and pronation, 10° of wrist extension and 60° of wrist flexion. He had full ROM and no obvious deformity in the middle finger (MF) and small finger (SF), which were non-pathologic. He had no motion at the distal interphalangeal joint (DIPJ) and slight flexion at the proximal interphalangeal joint (PIPJ) of his IF and RF. Left thumb exam revealed full metacarpal phalangeal joint (MCPJ) ROM; he had no motion at the thumb interphalangeal joint. **Differential Diagnosis:** Chondrosarcoma, thumb fracture, multiple enchondromatosis (Ollier's Disease) **Treatment:** Hand and thumb radiographs and MRI were reviewed and revealed bone cysts replacing nearly the entire thumb metacarpal shaft and both the proximal and distal thumb phalanx. The pathology report showed benign cartilaginous tumors. The diagnosis was severe enchondromatosis of left hand (Ollier's Disease), bacterial nail infection and inconclusive thumb distal phalanx fracture. Primary treatment included a thumb spica and oral antibiotics for nail infection. A three staged procedure was recommended. The first surgery included enchondroma excision of the thumb's distal phalanx, complete nail ablation, pedicled flap of IF to thumb for wound coverage and full-thickness skin grafting of IF. He was placed in a splint including

his thumb and IF with no ROM. Three weeks post-surgery, he underwent left IF 1st dorsal metacarpal artery flap take-down insetting. Two weeks post-surgery, full active and passive ROM began. The final surgery (two months after the first surgery) included excision of multiple enchondromas of the thumb's proximal and distal phalanx and repair with proximal tibial bone autograft (PTBG) and thumb IPJ fusion with PTBG. He was placed in a short arm thumb spica cast including his IPJ. At six weeks, he was placed into a forearm based thumb splint and began the return to play process. He was cleared with no restriction 4.5 months after the initial surgery and wears protection under his lacrosse glove on the left thumb. **Uniqueness:** Enchondromatosis is termed Ollier's Disease when multiple enchondromas have asymmetric distribution of cartilage lesions. Ollier's Disease consists of benign intra-osseous hyaline cartilaginous tumors[1]. This non-hereditary disease affects 1/100,000; males are affected twice as often as females. By age 40, 25% of cases will undergo a malignant change; this skeletal disorder needs to be monitored regularly. Due to the rarity of this condition, treatment options are patient specific and surgical intervention is only needed if the disease is complicated by pathological fractures. Bone cutterage is the most common treatment method for this disorder; due to multiple enchondromas in the thumb, this was not an option. Treatment of this disease includes level IV evidence and there is minimal research on athletes participating with this condition. **Conclusions:** Ollier's disease is a rare, non-hereditary disease. Surgical intervention is done when complications, such as pathologic fractures, are present. Athletic trainers need to be aware of this disorder as a differential diagnosis in athletes that present with deformity, persistent fractures with mild mechanisms of injury or generalized pain. With proper orthopeadic care and surgical intervention these individuals can compete in high level athletics. Continued treatment includes surgery on his IF, RF and scaphoid after his lacrosse season.

First Carpometacarpal Joint Dislocation in a Division I Football Athlete

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Background: A 20 year old male Division I football wide receiver was going for a pass when he fell to the ground on a flexed thumb. Athlete came in the next day complaining of snuffbox pain and there was a noticeable "clunk" with palmar glide of 1st carpometacarpal (CMC) joint. He presented with significant amounts of swelling over the thenar eminence and loss of function with his first phalanx. No prior history of any thumb sprains or other injuries. **Differential Diagnosis:** UCL sprain, bennett fracture, scaphoid fracture, scaphoid dislocation, 1st CMC dislocation, adductor pollicis longus strain/tear, flexor pollicis brevis strain/tear. **Treatment:** Athlete was referred for x-rays, which revealed a subluxated CMC joint with significant swelling consistent with CMC dislocation. An MRI confirmed the findings. Due to the location of the dislocation and amount of ligamentous damage, surgery was required to reduce and reconstruct the lateral side of his thumb. Athlete underwent an open reduction of his left thumb CMC joint with percutaneous pin stabilization. In addition, a ligament reconstruction of his thumb CMC anterior beak ligament using a split flexor carpi radialis (FCR) tendon transfer (eaton procedure) was performed. Athlete was immobilized for 6 weeks but was able to bike or elliptical for cardio. No running or lifting was allowed at this time. Six weeks status post-surgery, athlete went in for follow-up. X-rays confirmed good bony alignment and his hardware was removed. At this time, he was allowed to begin active range of motion and wear a custom splint as needed for soreness and areas at risk for high contact. He will be continuing to progress in the protocol as long as there are no complications. Athlete is currently progressing well. The next stage, at around ten weeks post operation will include the initiation of light strengthening. At twelve to fourteen weeks, the athlete can begin contact drills and blocking. At this time, he can be taped or splinted as needed. The advantage for this athlete is that he does not have to return to play until the spring season, therefore providing him with six months to rehabilitate before his return. However, the surgeon initially stated that twelve weeks total would be required for return to play which enables this injury to be treated more aggressively if desired. **Uniqueness:** An isolated 1st CMC joint injury is rare. Incidence makes up less than 1% of all hand injuries. The strong ligamentous structures and complex alignment of the carpal bones typically resist dislocation. If this injury goes neglected, one can have chronic instability, painful arthritis, muscle imbalances, and decreased grip strength. **Conclusions:** Isolated CMC joint dislocations are important to diagnose early. Inadequate treatment has shown to cause multiple complications later in life. At present, there is conflicting evidence on the most effective treatment for this injury, in regards to whether a conservative or non-conservative route should be taken. Ligament repair is associated with uniformly good results in various studies and the method of reconstruction tends to be based on the surgeon's discretion. Due to the important function of the thumb especially with gripping and grasping, this injury can present as a significant problem.

Reliability of Kinect-Based Markerless Motion Capture During Lower Extremity Tasks

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Context: Alterations in lower extremity kinematics during functional tasks have been commonly reported as risk factors for injury. While 3-Dimensional motion analysis systems (3DMA) are reliable and valid for assessments, several limitations have also been identified, such as high overall cost, clinician training, and limited portability. A markerless system that provides the advantages of laboratory-based motion analysis without the associated limitations would be ideal for field and clinical use. Previous studies that have evaluated this measurement technique to assess injury risk, have only focused on the hip and knee joints, although risk factors can propagate from the ankle or trunk as well. **Objective:** To compare peak sagittal and frontal plane lower extremity kinematics between the Vicon 3DMA and Microsoft Kinect™ motion capture system with custom Kinetech software during the bilateral squat and the drop vertical jump (DVJ). **Design:** Descriptive laboratory study. **Setting:** Laboratory. **Patients or Other Participants:** Thirty individuals volunteered to participate (25.66 ± 4.78 yrs, 1.71 ± 0.10 m, 73.31 ± 17.35 kg). **Interventions:** Participants completed three successful trials of the bilateral squat and the DVJ while being recorded simultaneously by the Vicon 3DMA (Vicon Motion Systems, Oxford, UK), and the Microsoft Kinect™ (v2, Microsoft Corp., Redmond, WA, USA). **Main Outcome Measures:** Peak sagittal and frontal plane trunk, hip, knee, and ankle kinematics were calculated for both systems. The reliability between the two measurement systems for each dependent variable was assessed using intraclass correlation coefficients ($ICC_{3,1}$), and the agreement between the two systems was evaluated with Bland Altman plots. **Results:** Sagittal plane kinematics were observed to be the most reliable between measurement systems across both tasks, at the hip (ICC_{squat}: 0.741-0.760, ICC_{DVJ}: 0.886-0.958), knee (ICC_{squat}: 0.907-0.920, ICC_{DVJ}: 0.877-0.944), and ankle (ICC_{squat}: 0.795 - 0.856, ICC_{DVJ}: 0.819 - 0.850). Kinematics were less reliable in the frontal plane across both tasks at the hip (ICC_{squat}: 0.246-0.357, ICC_{DVJ}: 0.077-0.080), knee (ICC_{squat}: 0.500-0.551, ICC_{DVJ}: 0.601-0.684), and ankle (ICC_{squat}: 0.143-0.477, ICC_{DVJ} : 0.052-0.127). Poor reliability between the systems was exhbited during both trunk flexion (ICC_{squat}: 0.005, ICC_{DVJ}: 0.002), and trunk lateral flexion (ICC_{squat}: 0.182, ICC_{DVJ}: 0.182) The average mean difference was generally smaller in the DVJ, yet the limits of agreement were wide across both tasks **Conclusions:** The Kinect reliably captures peak sagittal plane ankle, knee, and hip kinematics and frontal plane knee kinematics during both tasks, when compared to the gold standard optical 3DMA. Decreased ankle dorsiflexion range of motion has been suggested as a potential contributor to dynamic knee valgus, and this study was the first to show that the Kinect can accurately calculate this measurement. The utilization of this markerless assessment technique could be beneficial in a mass screening or pre-participation setting that requires lower extremity sagittal plane or knee valgus measurements, due to its time and cost-efficiency.

Reliability of an Ankle Arthrometer With External Strain Gauge for Quantifying Plantar Flexor Stiffness

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Context: Quantifying plantarflexor stiffness is a barrier to clinicians' and researchers' ability to understand dysfunction associated with ankle and lower leg pathologies. Deficits in dorsiflexion and associated plantarflexor contracture are linked to multiple injuries including ankle sprain and Achilles tendinopathy, but methods to quantify this dysfunction often lack reliability and/or rely upon indirect techniques. **Objective:** The aim of this study was to examine the reliability of a modified ankle arthrometer to quantify ankle dorsiflexion rotation and plantarflexor stiffness. **Design:** Reliability study. **Setting:** University laboratory. **Patients or Other Participants:** Ten healthy individuals without ankle impairment volunteered for this study (3M/7F, 21.4 ± 1.9 yrs, 65.0 ± 12.8 kg). **Interventions:** Participants were asked to lay supine on a padded table as their ankle was affixed to an instrumented ankle arthrometer (Blue Bay Research, Milton, FL). Attached to the arthrometer was a customized strain gauge designed to apply and measure a rotational force in the sagittal plane to the ankle joint. Using this device, two testers applied a dorsiflexion force to the ankle joint starting with the ankle neutral (10° plantarflexion). Forces were applied to torques of 10 and 20 Nm at loading rates of 2.5 and 5 Nm/sec, and the knee flexed 10 or 90° (8 total conditions). Five dorsiflexion loads were applied at each force combination by each examiner. The order of loading was randomized across participants. **Main Outcome Measures:** Peak dorsiflexion rotation (°) and total plantarflexor stiffness (Nm/°) served as

outcome measures. Rotation was measured using the 6-degree-of-freedom kinematic linkage system of the ankle arthrometer, while torque was quantified with the custom strain gauge. All data were collected simultaneously in a single LabVIEW program at 100 Hz. Intrarater reliability was assessed using intraclass correlation coefficients (ICC [2,k]), while interrater reliability was assessed using ICC [2,1]. **Results:** Peak dorsiflexion ranged from 4.78 ± 2.79° to 26.41 ± 9.64° for the different load combinations, with greatest values observed at 20Nm loads and 90° knee flexion. Intrarater reliability [ICC 2,k] ranged from 0.949 to 0.974, while interrater reliability [ICC 2,1] ranged from 0.766 to 0.910. Dorsiflexion stiffness ranged from 0.664 ± 0.23 Nm/° to 1.693 Nm/°, with greatest stiffness observed at 10Nm loads and 10° knee flexion. Intrarater reliability [ICC 2,k] ranged from 0.761 to 0.984, while interrater reliability [ICC 2,1] ranged from 0.274 to 0.914. The strongest overall reliability was observed at 5 Nm/sec and 20 Nm, at both 10° and 90° knee flexion. **Conclusions:** The use of an external strain gauge with an ankle arthrometer appears reliable for quantifying dorsiflexion rotation and plantarflexor stiffness in able-bodied participants. While quantification of maximum dorsiflexion was reliable across all load combinations, stiffness was observed to be most reliable when performed at a quicker rate and to a greater absolute load.

A Biomechanically Based Observational Tennis Serve Analysis Method is Reliable and Valid

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Context: An observational tennis serve analysis (OTSA) tool was developed using previously established body positions from three-dimensional kinematic motion analysis studies. These positions, defined as nodes, have been associated with efficient force production and minimal joint loading. However, the psychometric properties of the tool have not been established. **Objective:** 1) To determine the inter-observer reliability of OTSA tool, and 2) to investigate the discriminant validity of the OTSA. **Design:** Cross-sectional study **Setting:** Tennis Courts **Patients or Other Participants:** 4 health care professionals (2 athletic trainers and 2 physical therapists) and 4 tennis coaches served as observers to establish inter-observer reliability of the OTSA. Discriminant validity was determined using 35 non-professional tennis players. **Interventions:** Players were videotaped while performing 3 serves. Each player's United States Tennis Association National Tennis Ranking (USTA NTR) was recorded. Sixteen videos were randomly chosen, and independently rated on two separate days by 8 observers using OTSA tool. The tool assess the presence = 1 or absence = 0 for each of the nine nodes associated with the OTSA (foot position, knee position, 3 hip positions, 2 trunk positions, arm position, and the kinetic chain position) to evaluate serve mechanics. The highest score is 9 indicating the best mechanics. Observers were trained to detect these nodes during a classroom instructional training session using standardized operational definitions and videotaped examples of good and bad mechanics for each node. One HCP with excellent intra-rater reliability and experience with the OTSA graded 35 players tennis serves via video analysis. The players were subdivided into groups based off the NTR as low (≤3.5; 43 ± 14 years) and high (≥ 5.0; 20 ± 2 years). **Main Outcome Measures:** Each video was scored using the OTSA. Kappa coefficients (*K*) were used to determine reliability statistics. To determine the discriminant capability between NTR and the presence or absence of a particular node nine separate chi-square tests for independence were utilized. **Results:** Inter-observer reliability ranged from $K = 0.09$-0.72, with 8 out of the 9 nodes demonstrating moderate reliability or higher ($K > 0.41$). Six out of the nine nodes were able to discriminate between high and low ranked players ($p < 0.001$). **Conclusions:** The majority of the nodes associated with the OTSA were reliable indicating that multiple observers are able to detect the presence or absence of specific body positions during the serve using the OTSA. Node 5 evaluating forward hip lean should be removed from the OTSA as it demonstrated the lowest reliability and did not discriminant between player rankings. Lower ranked players did not adequately flex the knees and rotate the trunk during the service motion, which clearly discriminated them from high ranked players. This suggests the OTSA may provide a mechanism to identify deficits to improve performance.

Measuring Humeral Torsion With Ultrasound Using a One-Person Technique is a Reliable and Valid Technique

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Context: Overhead throwing athletes typically present with altered ranges of motion of the dominant shoulder as a result of osseous and soft-tissue adaptations. Total arc of motion deficits are attributed to soft-tissue restrictions and have been linked to injury. Knowledge of the amount of humeral torsion (HT) enables clinicians to implement appropriate interventions for soft-tissue restrictions in order to restore motion and reduce injury risk. While the current ultrasound method for measuring HT requires two trained assessors (2PT), a more efficient one-person technique (1PT) may be of value. **Objective:** To determine if a 1PT is a reliable and valid alternative to the established 2PT for indirectly measuring HT using ultrasound. **Design:** Repeated measures. **Setting:** Biomechanics laboratory. **Patients or Other Participants:** A convenience sample of 16 subjects (age = 26.9 ± 6.8 years; height = 172.2 ± 10.7 cm; mass = 80.0 ± 13.3 kg; sex = 7 males, 9 females) participated in this study. **Interventions:** HT data were collected using both the 1PT and 2PT ultrasound techniques from a total of 30 upper extremities (16 left, 14 right). Each extremity was considered as an independent measure. Measurements from an upper extremity were excluded if the subject reported any known history of fractures to the forearm or humerus, elbow or shoulder surgery within the past 6 months, or diseases that could affect normal bony anatomy. Each investigator was blinded to the results recorded by the other investigator. **Main Outcome Measures:** For both techniques, within-session intrarater reliability ($ICC_{3,1}$) was assessed across three trials. Precision was assessed using the standard error of measurement (SEM). Simple linear regression and Bland-Altman plots were used to examine validity of the 1PT when compared to the established 2PT. The SEM, simple linear regression, and Bland-Altman plots were calculated using mean values from three trials for both techniques. Alpha was set at ≤.05. **Results:** The mean HT measurement using the 1PT was 64.4° ± 9.5°, and 63.1° ± 9.6° for the 2PT. Both the 1PT ($ICC_{3,1}$ = .992, SEM = 0.8°) and 2PT ($ICC_{3,1}$ = .979, SEM = 1.1°) demonstrated excellent within-session intrarater reliability. The regression analysis demonstrated a strong linear relationship between the HT measurements collected with both techniques (r = .963, r^2 = 0.928, $F_{1,28}$ = 361.753, P < .001). The mean of the paired differences between the two techniques was -1.2° ± 2.6°, and the 95% limits of agreement indicated the two techniques can be expected to vary between -6.3° to 3.8°. **Conclusions:** The 1PT for measuring HT using ultrasound is a reliable and valid alternative to the 2PT. By reducing the number of testers involved, the 1PT may provide clinicians with a more efficient and practical means of obtaining this valuable clinical data.

Intrarater and Interrater Reliability of Diagnostic Ultrasound Measurements

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Context: Diagnostic ultrasound (DUS) is an imaging method with many potential benefits for use in clinical practice. Prior to utilization, the reliability of this modality should be determined to examine reproducibility within and between clinicians. Many studies have examined DUS reliability in various healthcare practitioners; however, limited evidence exists examining the reliability utilizing ATs. **Objective:** To determine the intrarater and interrater reliability of ATs ability to locate and measure structures using DUS. **Design:** Reliability study. **Setting:** Research laboratory. **Patients or Other Participants:** Twenty healthy participants (11 women and 9 men, BMI = 24 ± 2.38) volunteered as models. Three ATs credentialed ≤5 years with ≤5 hours total experience with DUS volunteered as raters (R1-R3). **Interventions:** Study procedures occurred over 4 sessions, each separated by 1-week. During session 1, raters participated in a training session which included instruction on how to use the DUS machine, videos describing how to locate the structures to be measured, and non-guided practice where the raters located and measured the structures until they felt comfortable. For sessions 2-4, each structure (patellar tendon (PT), acromioclavicular joint (AC), and median nerve (MN)), were measured twice on each model. A researcher recorded all measurements to blind the raters. Model order, as well as the order of the structures, were randomized. Each model reported for 2 consecutive data collection sessions. **Main Outcome Measures:** The dependent variable was measurement length (cm). Both PT and MN thickness was measured with the DUS probe placed cross-sectionally to the structure being measured and AC joint space was measured from the

clavicle to the acromion. The independent variables were time and rater (R1-R3). Intraclass correlation coefficients ($ICC_{2,1}$) were calculated to examine intrarater and interrater reliability. The ICCs were interpreted as poor (<0.39), moderate (0.40-0.59), good (0.60-0.79), and excellent (0.80-1.0). **Results:** The intrarater reliability for the PT ranged from moderate-good ($ICC_{2,1}$ = 0.53-0.76), AC from moderate-good ($ICC_{2,1}$ = 0.56-0.73) and MN from poor-moderate ($ICC_{2,1}$ = 0.38-0.48). The overall interrater reliability was good for the PT (ICC = 0.73, 95% CI = 0.42-0.88), excellent for the AC (ICC = 0.81, 95% CI = 0.60-0.92), and poor for the MN (ICC = 0.23, 95% CI = -0.64-0.67). **Conclusions:** These results indicate the intrarater reliability of recently credentialed ATs with limited DUS experience is clinically acceptable. In addition, the interrater reliability of the PT and AC were clinically acceptable. However, the MN exhibited poor reliability. This may be because ATs may not regularly examine this structure, nor is it easily palpable. These finding support the use of DUS in AT clinical practice without the need for extensive training or experience. Future research should continue to examine the reliability of other structures and the clinical utility of DUS in AT clinical practice.

Factor Analysis of the KOOS Does Not Indicate the Existence of 5 Unique Subscales

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Context: The Knee Injury and Osteoarthritis Outcome Score (KOOS) has become popular with clinicians and researchers for evaluating patient progress and overall treatment outcomes. Part of the appeal of the KOOS is its reporting of outcome scores for patients across 5 individual subscales – *Symptoms, Pain, Activities of Daily Living (ADL), Sports and Recreation,* and *Quality of Life (QOL)*. However, the uniqueness of the 5 subscales has not been well verified. **Objective:** The purpose of this study was to determine the number of latent factors evaluated by the KOOS. **Design:** Cross-sectional **Setting:** Orthopeadic Sports Medicine Clinic **Patients or Other Participants:** Patients undergoing ligament, meniscal, cartilage, or patellofemoral repair/reconstruction who were enrolled in a prospective orthopedic knee surgery outcomes registry were eligible for participation. Only patients with full preoperative KOOS data were include (n = 659, Male/Female = 303/356, 26 ± 12 yrs). **Interventions:** A maximum likelihood exploratory factor analysis was conducted on all 42 items of the KOOS with a direct quartimin rotation. **Main Outcome Measures:** The scree plot point of inflection method was used to determine the number of factors retained. Factor loadings below 0.3 were considered insignificant and were suppressed. **Results:** Sampling adequacy was verified by the Kaiser-Meyer-Olkin measure (KMO) = 0.956. The scree plot clearly demonstrated that no more than 2 factors, and perhaps only 1 factor, should be retained (Initial Eigenvalues: Factor 1 = 20.8, Factor 2 = 2.6). The two factors combined explained 53.6% of the variance. All questions from the *ADL* subscale along with most questions from the *Symptoms, Pain*, and *QOL* subscales loaded on Factor 1. After rotation, the highest loadings on Factor 1 were observed for questions related to function and/or pain while sitting, standing, walking, and rising from bed. All items on the *Sports and Recreation* subscale and the questions regarding "pain with twisting/pivoting", "swelling in your knee", and "How often are you aware of your knee problem?" clustered on Factor 2. The *Symptoms* questions related to range of motion were the only questions that did not contribute significantly to either factor. **Conclusions:** Despite being reported as 5 separate subscale scores, the KOOS appears to evaluate two main factors "Pain and Function during ADLs" and "Function during Sports and Recreation." These results, documented among knee surgical patients, are in line with other recent adaptations of the KOOS (KOOS-JR and KOOS-PS) which were developed via item reduction of some, but not all subscales, and have been proposed for use in osteoarthritic and total knee arthroplasty patients. The results of this investigation indicate that item reduction of the full KOOS and the collapsing of subscales into no more than two domains may be warranted. Such a reduction has the potential to reduce both patient and clinician burden, while simplifying KOOS interpretation by eliminating redundant or non-discriminant questions.

Landing Mechanics During a Drop Vertical Jump (DVJ) Can Be Reliably Captured Across a Sports Season Using 2-Dimensional (2D) Motion Capture

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Context: Risky joint motions during a DVJ landing, such as increased frontal plane projection angle(FPPA) and limited knee flexion angles(FLEXION), are potentially modifiable. 2D motion capture is reasonably valid compared to 3D, and is reliable when tested less than 1 week between sessions. Reliable and sensitive techniques, capable of capturing biomechanical changes due to injury risk or intervention, are necessary to determine if meaningful movement alterations are occurring. **Objective:** Evaluate long-term responsiveness of 2D motion analysis. **Design:** Reliability study. **Setting:** Field testing. **Patients or Other Participants:** Nineteen female high school basketball athletes (ages: 14-18yrs). **Interventions:** At pre- and post-season testing, each participant completed 3 two-footed DVJ tasks consisting of the subject dropping from a 31-cm platform, landing on 2 feet, and immediately jumping vertically with arms elevated. Each trial was recorded simultaneously with 2 video cameras set on tripods. One camera was positioned 345-cm anterior to the platform; the other positioned laterally, 345-cm from the platform to the participant's left. For each DVJ captured, 2 images were extracted: just prior to weight acceptance (Initial) and final downward motion (MaxDepth). **Main Outcome Measures:** Joint angles were measured at Initial and MaxDepth using ImageJ. In the lateral view, FLEXION(°), formed by the intersection of two lines (greater trochanter to knee joint center, knee joint center of lateral malleolus), was measured, and averaged across the participant's 3 trials. This was repeated for the anterior view. FPPA (°), formed by intersection of two lines (ASIS to the knee joint center, knee joint center to mid-malleoli), was measured. Pre- and post-season measurements were separately contrasted using paired t-tests. Separate intraclass correlation coefficients ($ICC_{2,3}$) with standard error of the measure (SEM) were used to determine the relationship between pre- and post-season. Minimal detectable differences (MDD) were calculated. Alpha level was set at $p < 0.05$. **Results:** ICCs [SEM] and means [stdevs] are presented. In the lateral view, strong reliability was observed between pre- and post-season for Initial ($ICC_{2,3}$ = 0.79 [3.4], MDD = 4.8°, $p < 0.001$) and MaxDepth ($ICC_{2,3}$ = 0.79 [4.6], MDD = 6.4°, $p < 0.001$). There were no significant differences in FLEXION between preseason and postseason at Initial (153.5 [6.5]° vs. 152.1 [6.8]°, p = 0.20) or at Max Depth (93.1 [7.9]° vs. 92.4 [11.7]°, p = 0.70). In the anterior view, strong reliability was observed between pre- and post-season for Initial ($ICC_{2,3}$ = 0.84 [1.4], MDD = 2.0°, $p < 0.001$) and MaxDepth ($ICC_{2,3}$ = 0.72 [4.8], MDD = 6.8°, $p < 0.001$). There was a significant difference in FPPA between preseason and postseason at Initial (172.6 [2.4]° vs. 171.3 [3.3]°, p = 0.02), but not for MaxDepth (162.4 [6.8]° vs. 160.2 [7.8]°), p = 0.18). **Conclusions:** Biomechanical analyses can be effective for identifying those at-risk, but must be accessible to clinicians. These results indicate that 2D motion analysis captures a stable representation of landing mechanics over the course of a sports season with approximate MDDs of 2 to 7°. This method can provide reliable data over time and has potential to detect reasonably small changes in landing technique.

Correlations Between Arthrometer-Measured Plantarflexor Stiffness, Ligamentous Laxity, and Range-of-Motion at the Ankle

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Context: Ankle arthrometry has offered clinicians and researchers insight into the role of static restraint in injury prevention and rehabilitation by quantifying anteroposterior (AP) and inversion-eversion (IE) laxity and stiffness. Although these measures are believed to strictly quantify ligamentous laxity, muscular stiffness such as that from ankle plantarflexors has been hypothesized to affect joint laxity. However, until recently it was not possible to quantify plantarflexor stiffness using an ankle arthrometer. **Objective:** To examine the relationships between arthrometer-derived plantarflexor stiffness with ankle laxity and range-of-motion. **Design:** Correlational. **Setting:** University laboratory. **Patients or Other Participants:** Ten healthy individuals volunteered for this study (3M/7F, 21.4 ± 1.9 yrs, 65.0 ± 12.8 kg). Participants were free of lower limb pathology for 12 months prior to testing and scored >90% on the Foot & Ankle Ability Measure. **Interventions:** Participants lay supine on a padded table as an instrumented ankle arthrometer was affixed to the ankle. Trained investigators applied five AP translations (-30 to 130 N, 50 N/sec) and five IE rotations (-4.2 to 4.2 Nm, 1 Nm/sec) to the ankle. An external strain gauge customized to apply a sagittal torque was affixed to the casing of the arthrometer and synchronized with its recordings. Using this device, five rotations (20 Nm, 5 Nm/sec) in the direction of dorsiflexion were applied to the ankle joint, starting with the ankle in neutral (plantarflexed 10°). This was repeated with knee flexed 10° and 90°. Dorsiflexion range-of-motion was further assessed using a weight bearing lunge (WBL). **Main Outcome Measures:** Peak AP

displacement (mm), inversion, eversion, and dorsiflexion rotation (°) were extracted, as well as plantarflexor stiffness (Nm/°). Stiffness was determined as change in force divided by change in rotation for the entire rotation, as well as during the first and last seconds. WBL distance (cm) was used a clinical measure of dorsiflexion range-of-motion. Relationships between dorsiflexion variables and AP, IE, and WBL measures were assessed through Pearson correlation coefficients ($\alpha = 0.05$). **Results:** Peak dorsiflexion was 19.3 ± 7.6° and 26.1 ± 9.1° with the knee straight and flexed, respectively. Plantarflexor stiffness was 0.875 ± 0.37 Nm/° and 0.673 ± 0.21 Nm/° with the knee straight and flexed, respectively. Significant correlations were observed between maximum dorsiflexion at 10° knee flexion and AP displacement ($r = 0.666$, $p = 0.035$) and WBL distance ($r = 0.681$, $p = 0.030$). Dorsiflexion stiffness with 90° knee flexion correlated with WBL distance ($r = -0.665$, $p = 0.036$), while short-range dorsiflexion stiffness with the knee flexed 90° correlated with AP displacement ($r = -0.637$, $p = 0.048$). No significant correlations were observed for IE measurements. **Conclusions:** Greater dorsiflexion and less plantarflexor stiffness correlated with greater AP displacement and WBL performance, but had no relationship with IE rotation. This provides evidence that plantarflexor stiffness may serve to modify AP translation of the ankle. This data also provide evidence supporting concurrent validity between arthrometer-derived measures of sagittal plane ankle stiffness and WBL performance.

The Effect of Kinesio Tape® on Intramuscular Tissue Temperature Change During a 20-Minute Cryotherapy Application

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Context: Cryotherapy is the most commonly used modality by athletic trainers for management of musculoskeletal injuries. One factor that can alter the effectiveness of cryotherapy on intramuscular temperature is barriers (e.g., tape) placed between the skin and cryotherapy mechanism (e.g., ice bag). As Kinesio® Tape has become more prevalent, research is warranted to investigate the claim by the manufacturer that Kinesio® Tape is not a barrier for cryotherapy treatment. **Objective:** To compare intramuscular temperature change during a 20-minute cryotherapy session with and without Kinesio® Tape application. **Design:** Randomized, within subject, experimental. **Setting:** Laboratory at a research university. **Patients or Other Participants:** Twenty males (Age: 21.3 ± 2.83; Height: 72 ± 2.64 in; Weight 182.05 ± 23.246 lbs) participated in the research protocol. Participants were excluded if there were contraindications to cryotherapy or Kinesio® Tape. Participants were also excluded if there was more than 1.5 cm of adipose tissue as quantified by musculoskeletal diagnostic ultrasound or injury to the quadriceps within the previous six months. **Interventions:** Participants were asked to report for two separate sessions one week apart. Participants served as their own control and were randomized into two groups: Kinesio® Tape applied during the first session or second session. Kinesio® Tape was applied from the origin to insertion of the rectus femoris and vastus medialis oblique muscles. Temperature recordings of intramuscular tissue temperature 1 cm below adipose was recorded using thermocouples connected to an Iso-Thermex electronic thermometer (Columbus Instruments, Columbus, OH 43204 U.S.A.). Data were collected every 30 seconds for a three-minute baseline and a 20-minute treatment time. **Main Outcome Measures:** Intramuscular tissue temperature 1 cm below adipose with and without the Kinesio® Tape application was recorded for the rectus femoris and vastus medialis oblique. Data were analyzed with a repeated measures ANCOVA. The independent variable of was the taping condition, and temperature was the dependent variable while BMI served as a covariate. **Results:** Each participant was measured a total of 41 times (from baseline measurement in 30 second increments for 20 minutes). Results indicate a significant effect due to time ($F[40,1556] = 1.53$, $P = .019$). BMI was not a statistically significant covariate ($F[1,1556] = .996$, $P = .319$). Taping condition was not a statistically significant factor ($F[1,1556] = .66$, $P = .417$). **Conclusions:** Results indicate the application of Kinesio® Tape did not lead to a statistically significant difference in intramuscular temperature recordings after controlling for BMI. Intramuscular temperature for each group fell over time, but the pattern between the groups was indistinguishable. This result lends credence to the claim of the tape›s developer that ice can be applied over Kinesio® tape without substantial differences in temperature. Further research should focuse comparing different types of tape (e.g., Rock Tape) on the effects that occur during cryotherapy.

Kinesio Tex Tape Does Not Improve Sensorimotor Function in Participants With Chronic Ankle Instability

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Context: CAI is a condition associated with sensorimotor dysfunction often quantified as impaired postural control. Poor static and dynamic postural control is associated with an increased risk of lateral ankle sprains. Kinesio Tex (KT) Tape is purported to improve sensorimotor function and thus may be an effective intervention to help improve dynamic postural control in those with CAI. **Objective:** To determine if KT tape improves dynamic postural control and perceived stability more than traditional athletic tape or no tape in those with CAI. **Design:** Crossover. **Setting:** University research laboratory. **Patients or Other Participants:** Twenty-four individuals (age: 21.25 ± 3 years, height: 173.14 ± 10 cm, weight: 67.95 ± 12.70 kg) with CAI (IdFAI score = 20.29 ± 4.27, FAAM = 85.7 ± 12.0%, FAAM-S = 76.3 ± 15.7%) participated. **Interventions:** A traditional basket weave was the traditional athletic tape condition. KT tape consisted of three strips that started medially and finished on the lateral aspect of the ankle and lower leg. The final strip crossed the dorsum of the foot. The control condition consisted of sitting quietly for 5 minutes. **Main Outcome Measures:** SEBT reach distance normalized to limb length in the anterior ($SEBT_A$), posteromedial ($SEBT_{PM}$), and posterolateral ($SEBT_{PL}$) directions. Time-to-Boundary (TTB) minima means in the anteroposterior (AP) and mediolateral (ML) reach directions. Perceived instability (cm) of the ankle was measured using a 10cm visual analog scale (VAS). Repeated measures ANOVAs

determined differences in perception of stability and repeated measures MANOVAs determined differences in postural control outcomes between taping conditions. **Results:** The $SEBT_A$ reach direction was reduced in the standard tape condition (60.5 ± 6.8%) relative to the KT Tape condition (67.8 ± 4.5%, $P < 0.01$, d = 1.17), Baseline condition (68.9 ± 5.5%, $P < 0.01$, d = 1.36), and the Control condition (68.1 ± 5.4%, $P < 0.01$, d = 1.24). There was no difference among KT Tape, baseline, and control conditions ($P > 0.05$) in the $SEBT_A$ direction. In the $SEBT_{PL}$ direction, Standard Tape (95.6 ± 11.0%) significantly reduced reach distance relative to baseline (99.3 ± 10.2%, $P < 0.05$, d = 0.35) and KT Tape (100.5 ± 10.3%, $P < 0.01$, d = 0.47). In the $SEBT_{PL}$ direction, there was no difference among KT Tape, baseline, and control conditions ($P > 0.05$). No differences existed among the baseline, KT Tape, standard Tape, and control conditions ($P > 0.05$) in the $SEBT_{PM}$ direction. No differences in AP (Baseline: 5.0 ± 1.6 s, KT Tape: 5.2 ± 1.7 s, Standard Tape: 5.1 ± 1.5 s, Control: 5.1 ± 1.7 s) or ML (Baseline: 1.9 ± 0.6 s, KT Tape: 1.9 ± 0.5 s, Standard Tape: 2.2 ± 0.6 s, Control: 1.9 ± 0.6 s) TTB scores were observed. Both KT Tape (6.7 ± 1.7 cm) and standard Tape (7.2 ± 2.5 cm) resulted in higher levels of perceived stability ($p < 0.01$) relative to the baseline (4.8 ± 1.7 cm) and control (5.4 ± 2.0 cm) conditions. **Conclusions:** Standard tape reduces $SEBT_A$ and $SEBT_{PL}$ reach distances, likely due to restricting dorsiflexion range of motion. KT tape does not improve postural control relative to a no tape condition. Both Standard and KT tape improved perceived stability relative to the baseline and control conditions despite different application techniques. More evidence is needed to support the use of KT tape for CAI.

Alpha Motoneuron Excitability of the Soleus Following Application of Kinesiology Tape to the Calf

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Context: Kinesiology tape (KT) can be applied to the skin in different directions and with varying degrees of tension for the purpose of promoting either muscle facilitation or inhibition. No research has been conducted to test these application techniques based on plasticity in the spinal cord. **Objective:** To evaluate how changing tension and direction of KT alters alpha motoneuron excitability in the spinal cord as measured by the Hoffmann reflex. **Design:** Crossover Study **Setting:** Research Laboratory **Patients or Other Participants:** Seventeen healthy, physically active adults with no history of ankle sprains, displaced fractures, or lower extremity surgeries (10 Men, 7 Women, 22.4 ± 4.6 years, 170.2 ± 8.6 cm, 72.7 ± 14.5 kg) volunteered for this study. **Interventions:** Each participant received five different KT applications to the calf that varied according to the degree of tension and direction of pull: 1) No tape (NT), 2) Low tension from origin to insertion (L-OI), 3) Low tension from insertion to origin (L-IO), 4) High tension from origin to insertion (H-OI), and 5) High tension from insertion to origin (H-IO). **Main Outcome Measures:** Ten minutes post each KT condition, soleus H-reflex and M-wave recruitment curves were obtained by stimulated the tibial nerve as subjects performed a 60% maximum voluntary isometric contraction. Maximal H-reflex and maximal M-wave values were identified and H/M ratios were calculated for data analysis. A repeated measures ANOVA was conducted to determine if H/M ratios differed between taping conditions. Additionally, we were interested in determining if a subject's baseline H/M ratio (NT condition) affected their overall response to KT. We also calculated four Pearson product-moment correlation coefficients to compare H/M ratios from the NT condition to the H/M ratios of the L-OI, L-IO, H-OI, and H-IO conditions. An a priori alpha level of $p < .05$ was set for all statistical analyses. **Results:** There was no significant difference in soleus H/M ratios between the five KT conditions (NT mean = 52.0 ± 19.9, L-OI mean = 55.0 ± 18.1, L-IO mean = 52.1 ± 17.7, H-OI mean = 52.0 ± 18.6, and H-IO mean = 55.6 ± 16.9; $p > .05$). However, we found negative relationships for all four Pearson correlations, with the NT/L-IO ($r = -.487$; $p = .047$) and NT/H-IO ($r = -.576$; $p = .016$) correlations reaching significance. **Conclusions:** Altering the application parameters according to degree of tension or direction of pull does not affect spinal cord plasticity alone. Instead, applying KT to the skin may impact alpha motoneuron excitability differently according to the patient's baseline H/M ratio. Subjects with a lower H/M ratio without tape are more likely to experience facilitation following KT application to the calf, while those with higher baseline ratios will likely experience inhibition.

Efficacy of Kinesiology Taping as an Adjunct Treatment of Shoulder Impingement Syndrome: A Systematic Review

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Context: Shoulder pain is a common complaint, with the prevalence ranging between 7% and 36%. Shoulder impingement syndrome is reported as one as the major causes of this complaint. There are various options for the conservative treatment of this ailment aimed at reducing pain and restoring normal range of motion, but kinesiology tape is one option growing in popularity. Current literature is inconclusive as it pertains to the reduction of symptoms associated with shoulder impingement syndrome. **Objective:** The purpose of this systematic review was to determine if kinesiology tape can improve range of motion, subacromial space, and subjective function as an adjunct treatment in individuals with shoulder impingement syndrome **Data Sources:** PubMed and EBSCOhost (CINAHL, MEDLINE, SPORTDiscus) databases from inception to November 2015 were systematically searched, and limited to English. The key words used were kinesiotape, KT tape, kinesiology tape, shoulder, and shoulder impingement. **Study Selection:** Studies were included if kinesiology tape was used as a treatment for symptoms of shoulder impingement. Studies were also required to have outcome variables with pre- and post-intervention data including shoulder range of motion, acromiohumeral space, visual analogue scale (VAS), and Disability of Arm, Shoulder, and Hand (DASH) scores. Studies were excluded if any other body part besides the shoulder was observed, or if the symptoms of shoulder impingement were not addressed. **Data Extraction:** All articles were screened by four reviewers for inclusion criteria and methodological quality using the Physiotherapy Evidence Database (PEDro) scale. Means and standard deviations were extracted to calculate Cohen's d effect sizes with 95% confidence intervals for all variables. **Data Synthesis:** The search revealed 21 potential studies and five met the criteria, with an average PEDro of 5/10. Large effect sizes were identified in range of motion with the combined treatment of kinesiology tape and mobilization with movement, in both shoulder flexion (d = 3.65, CI = 2.44-4.87) and abduction (d = 5.00, CI = 3.22-6.76). Acromiohumeral space also improved with two different kinesiology tapings compared to sham taping with strong effect sizes of 1.28 (CI = 0.55-2.03) and 0.98 (CI = 0.23-1.74), respectively. Small effects were found in subjective function with the DASH (d = 0.20, CI = -0.34-0.73) and pain when assessed by the VAS (d = 0.14, CI = -0.39-0.67) between kinesiology taping and manual therapy. **Conclusions:** Kinesiology tape may be effective in reducing impairments, such as altered range of motion and decreased subacromial space, commonly associated with shoulder impingement syndrome. However, these improvements were only identified when used as an adjunct treatment. These results also do not indicate that kinesiology tape has a clinically significant effect at improving subjective function. Future research should look into the treatment of kinesiology tape alone, rather than in conjunction with other interventions to examine the effectiveness of this intervention when treating patients with shoulder impingement syndrome.

Student Athlete Knowledge of Athletic Trainer's Scope of Practice

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Context: Athletes have previously reported overall satisfaction with the quality of care received from their athletic trainer. High-profile sports, such as football, men's basketball or baseball, and women's basketball report the highest amount of satisfaction. Knowledge/skills, availability, and communication were reported as desirable characteristics of an athletic trainer. Despite this information, little to no studies have been conducted to investigate athletes' knowledge of the athletic trainer's scope of practice. **Objective:** Determine athletes' knowledge of athletic trainer's scope of practice. **Design:** Prospective sequential explanatory mixed methods design. **Setting:** Online survey delivered through university email system. **Patients or Other Participants:** Convenience sample of 108 NCAA Division I student athletes. 44 incoming freshman student athletes were recruited. Response rate: 41%. Groups were formed based on previous experience with an athletic trainer in high school and sport profile. **Interventions:** A 26 question survey was administered online through email delivery to incoming freshmen student athletes. Survey consisted of demographic information and knowledge sections. Independent variables were previous experience with an athletic trainer and sport profile. **Main Outcome Measures:** Demographic data was analyzed using descriptive statistics. Knowledge questions were summed to create a total score. Independent t-tests were run to compare knowledge scores between athletes with or without previous experience with athletic trainer and high- and low-profile sport groups, with alpha set to 0.05. **Results:** 90.9% of participants were 18 years old. 59% female and 40.9% male. 64% of participants had previous experience with an athletic trainer, while 36% had no previous experience. Of the participants that previously interacted with an athletic trainer, 64% interacted with their athletic trainer at least 1 time per week, for injury evaluation, treatment and rehab, and injury prevention. Participants that did not have an athletic trainer reported their injuries to their parents and coaches (33%), and physicians (20%). Means comparisons revealed no significant differences in knowledge scores with regard to previous experience with an athletic trainer ($p = 0.65$) or sport profile ($p = 0.38$). All participants had a mean score of less than 70% on the knowledge section. 91% of participants, regardless of group, were unable to correctly identify what the ATC credential represented. Only 59% of participants were able to recognize that athletic trainers must pass a national exam before achieving certification. **Conclusions:** Knowledge of athletic trainer's scope of practice is not dependent upon previous experience. General knowledge in this sample was low, suggesting that athletes may not be well educated on all aspects of an athletic trainer's role in athlete health and wellness. Clinicians should consider educating athletes on scope of practice, as It is possible that a higher level of knowledge might improve satisfaction and provide quality healthcare among athletes.

Is There a Correlation Between Preceptor Modeling of Spiritual Therapeutics and Athletic Training Student Actions?

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Context: Past research on spiritual care in athletic training (AT) has demonstrated that while ATs acknowledge the therapeutic importance of spiritual care in holistic well-being, they are hesitant to incorporate spiritual care in their own practice. It may be that a lack of training or modeling of these behaviors contributes to clinician hesitance. Thus, we sought to investigate if student exposure to preceptor modeling of spiritual care therapeutics influenced their own practice. **Objective:** To assess for correlation between preceptor modeling of spiritual care therapeutics during clinical experiences and athletic training student (ATS) self-reported use of spiritual care therapeutics. **Design:** Cohort **Setting:** Online survey **Patients or Other Participants:** A convenience sample of all ATS ($n = 33$) at a single university were invited to participate in an online survey. Thirty-one (94%) responded (age = 20.2 years, males = 11, females = 20). **Interventions:** Participants were recruited via email, and an announcement made in their clinical education course to complete an online survey (using Qualtrics survey software). The survey included a demographic background section and the modified Spiritual Care Therapeutics Scale (mSCTS), which was completed twice; once for modeled preceptor actions and once for ATS actions. The 14-item mSCTS scale documents how frequently certain spiritually related patient care actions are employed in clinical practice. It is previously validated in the nursing literature for content validity and reliability (Chronbach's alpha = 0.93), and the current modified version replaced the word "nurse"

with the more generic term "clinician" and removed 4 items that only apply to hospital nursing. **Main Outcome Measures:** The mSCTS scoring was 1 = never, 2 = rarely, 3 = occasionally, 4 = often, 5 = very often. For each survey item, a Spearman rank correlation was used to assess for correlation between preceptor modeling and ATS actions, then organized from weakest to strongest. **Results:** Every surveyed item in mSCTS showed a significant correlation between preceptor modeling and ATS actions (all $p \leq 0.05$). The four strongest correlations were "encouraged a patient to talk about what gives his or her life meaning amidst injury/illness" ($r_s = 0.678$, $p < 0.001$), "encourage a patient to talk about the spiritual challenges of living with injury/illness" ($r_s = 0.638$, $p < 0.001$), "helped a patient have quiet time or space ($r_s = 0.633$, $p < 0.001$), and "discussed a patient's spiritual care needs with colleague's" ($r_s = 0.603$, $p < 0.001$). The four weakest correlations, yet still significantly associated were "encouraged a patient to talk about how injury/illness affects related to God" ($r_s = 0.490$, $p = 0.005$), "prayed for a patient" ($r_s = 0.488$, $p = 0.006$), "offered to read a spiritually nurturing passage" ($r_s = 0.391$, $p = 0.030$), and "listened actively for spiritual themes in a patient's story of injury/illness" ($r_s = 0.387$, $p = 0.034$). **Conclusions:** Preceptor modeling of spiritual therapeutics seems to directly impact ATS actions in all areas surveyed. Additional research could explore the impact clinical setting, educational institution, and years of experience play for both preceptor and ATS.

Perceptions of Athletic Trainer Abilities to Perform Skills Outlined in the BOC Practice Analysis

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Context: Athletic trainers have long been involved with highlighting the distinctions of the athletic training profession in relation to other professions. The Board of Certification's *Practice Analysis* (PA) provides five distinct domains designed to identify essential knowledge and skills for the athletic training profession. Whereas the domains are designed specific to the field of athletic training it could be expected that athletic trainers are perceived as most able to perform the skills outlined in the PA. **Objective:** Because "athletic trainer" is not mentioned specifically in each domain of the PA, the goal of this study was to determine how athletic trainers are perceived against other professions specific to ability to perform each PA domain. **Design:** Cross-sectional design in conjunction with a web-based survey of a large undergraduate population. **Setting:** Electronic survey **Patients or Other Participants:** Students enrolled in a large (enrollment = 1,800) undergraduate class at a highly diverse university were asked to participate in the survey. A total of 948 responses (53% response rate) representing a highly diverse (e.g. 62% female, variety of ethnicities, all undergraduate classes and majors) population were analyzed. **Interventions:** Students were asked to rank (order) 10 healthcare professions from "1" (most qualified) to "10" (least qualified) for each of the five PA domains according to the student's perception of each profession's ability to perform each domain. Respondents were not informed that the domains were specific to the field of athletic training. The healthcare professions were taken from the US Bureau of Labor Statistics' classification of "Healthcare Occupations" that required at least a bachelor's degree, along with "EMT/Paramedic" due to the "Emergency Care" PA domain. For the survey, each domain was written verbatim from the PA (version 7) to include both the domain topic (e.g. "Therapeutic Modalities") as well as the accompanying description. **Main Outcome Measures:** For each domain, mean rank value was calculated for each profession. Athletic trainer rank among other professions was reported. **Results:** Specific to perceived ability to perform each domain, athletic trainers ranked 3rd at injury and illness prevention and wellness protection, 9th at examination, assessment, and diagnosis, 7th at emergency care, 5th at therapeutic modalities, and 10th at healthcare administration. **Conclusions:** Despite being judged against domains established by their own certification board, athletic trainers were perceived as being no higher than third (Injury and Illness Prevention and Wellness Protection) and as low as tenth (Healthcare Administration) at being able to perform the domains listed in the PA compared to other healthcare professions. These findings highlight that the membership and administration of the NATA must continue to work to improve the perception of the knowledge and skills of athletic trainers required to perform the skills outlined in the PA.

Athletic Trainers' Perceptions and Experiences of Withholding Athletes From Participation

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Context: Athletic trainers (ATs) frequently have to make quick decisions that affect the well-being of athletes. Decision-making around withholding athletes is complex and may be influenced by a variety of factors, such as pressure. Previously, a link between feelings of pressure to prematurely return to the playing field from a concussion has been shown in athletes. However, pressure on ATs themselves to make appropriate decisions to withhold an athlete from participation has not yet been examined. **Objective:** To explore ATs' perceptions and experiences of withholding athletes from participation including the identification of factors which may impact the ability to make appropriate decisions. **Design:** This qualitative investigation included a consensual qualitative research tradition/framework based in phenomenology and grounded theory. **Setting:** Individual phone interviews were conducted with all participants. **Patients or Other Participants:** 10 ATs (6 females, 4 males; age = 34.0 ± 9.8 years; AT experience = 12.0 ± 10.4 years), representing 17 sports were interviewed achieving saturation. Participants were recruited with convenience sampling. **Data Collection and Analysis:** A single semi-structured phone interview (12 questions) was conducted with each individual participant and then transcribed verbatim. A 3-person research team coded the data into themes and categories individually and met to determine final consensus to ensure the accuracy and comprehensiveness of the data. Multiple research team members were utilized as well as the incorporation of participant member-checking and an internal auditor to control for bias. **Results:** Overall, participants highlighted four main areas which may impact their decision-making strategies. Collaboration referred to the communication and relationship with other members of the sports medicine team, administration, coaches, parents, and athletes themselves. The participants also described specific injury factors such as injury types (ex: concussion) and characteristics (ex: visible) impacting the decision to withhold an athlete for the AT as well as the degree to which a participant is withheld. Demographic factors included characteristics relating to sport, environment, the athlete, competition, level of participation, and external influences (eg. media and community involvement). Lastly, components of and preparedness for decision-making were discussed. Items such as the team member role, legal implications, justification of their decision, and their own baseline perceptions of withholding were also described. For preparation, ATs specifically described their own education, education of team members (i.e. coaches and parents), and the incorporation of policies and procedures as vital to being able to make appropriate medical decisions. **Conclusions:** These findings suggest that organizational and individual efforts are key to improve the establishment of collaborative relationships in the sport environment and culture relative to return to play decision-making. Other factors such as specific sport, injury type, and individual education may also play a role. Future research is needed to determine which of these relationships and/or factors are most predictive of deviation from best-practices.

Roles and Responsibilities of Individuals Within the Academic Setting Who Hold the Doctor of Athletic Training Degree

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Context: Due to a shortage of athletic training faculty with terminal degrees and an increasing need for more doctoral-educated athletic trainers, the Doctor of Athletic Training (DAT) degree has been proposed as an additional option for advancing education beyond the entry-level competencies. It is pertinent to understand the value the DAT will have for those interested in pursuing the degree, particularly those with an interest in employment within academe. **Objective:** To determine the roles and responsibilities that an individual who holds the DAT degree would perform within the academic setting. **Design:** Cross-sectional **Setting:** Online survey **Patients or Other Participants:** A list of 376 department chairs with oversight of professional athletic training programs was obtained from the Commission on Accreditation for Athletic Training Education. 190 (50.5%) accessed the survey and 151 (79.5%) completed all parts of the survey (72 public and 77 private institutions). **Interventions:** The survey consisted of two sections; institutional demographics and DAT specific questions. Within the DAT specific question section, department chairs were asked to select all of the types of faculty lines that were available within their unit. Faculty lines included lecturer/instructor line, clinical faculty line, research faculty line, and tenure-track line. After identifying available lines department chairs selected all roles and responsibilities they would expect an individual to perform within a given line. Roles and responsibilities included advising, teaching, scholarship, clinical service, and community service. Lastly, department chairs were asked to identify

the primary role they would expect an individual to perform within each faculty line. A panel of experts in athletic training education established content validity of the survey. **Main Outcome Measures:** The primary outcome measure was to identify the roles and responsibilities that an individual holding a DAT degree would be expected to perform within the academic setting based on specific faculty lines available at institutions. Descriptive statistics were used to characterize all variables. **Results:** Teaching was identified as the primary role expected of an individual when hired within a lecturer line, clinical faculty line, or tenure-track line. The primary responsibility identified for individuals within a research faculty line was scholarship. The terminal research degree (PhD) was the most commonly chosen option for all faculty lines, however department chairs reported the DAT was a viable degree for hiring an individual into a lecturer/instructor line (n = 69/131, 52.7%), clinical faculty line (n = 37/69, 53.6%), research faculty line (n = 8/32, 25%), and tenure-track line (n = 63/139, 45.3%). Most (81%) department chairs reported that an advanced degree was required to teach. **Conclusions:** The DAT degree is a viable option for individuals interested in pursuing a career in academe and would align with various faculty lines, particularly instructor or clinical faculty positions that place emphasis on the role and responsibility of teaching.

Employability of Individuals in Academe Who Hold the Doctor of Athletic Training Degree

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Context: The professional athletic training (AT) degree will move to the post-baccalaureate level by 2022. Limited literature exists regarding factors which will be affected by this change in regards to academic positions as related to programmatic teaching needs **Objective:** To identify department chairs perceptions of the Doctor of Athletic Training (DAT) degree and determine the viability of employment within academic positions. **Design:** Cross-sectional **Setting:** Online Survey **Patients or Other Participants:** A list of 376 department chairs with oversight of professional athletic training programs was obtained from the Commission on Accreditation for Athletic Training Education. 190 (50.5%) accessed the survey and 151 (79.5%) completed all parts of the survey (72 public and 77 private institutions). **Interventions:** A web-based survey instrument was distributed via Qualtrics (Qualtrics, LLC, Provo, UT), which included demographic questions and 4-point Likert-scale items related to perceptions of the DAT degree was completed by department chairs. The areas addressed within the Likert questions focused on familiarity of educational changes, likelihood to hire clinical degree faculty, and likelihood to hire athletic trainers with a DAT degree. The instrument was distributed to 3 experts in AT education who critiqued the questions for wording and repetition. The survey instrument was then pilot tested by experts in AT research who had experience in research content and design. This feedback was used to revise wording and content for the final instrument. **Main Outcome Measures:** Independent variables included institutional control, student enrollment, degree granting classification, faculty with a clinical doctorate, and advanced degree requirements. The dependent variables were the department chairs' responses to the survey items. Descriptive statistics were used to calculate all variables and non-parametric statistics were used to assess differences ($P < .05$). **Results:** More than 80% of department chairs were moderately or extremely familiar with the concept of a clinical doctorate degree and 64% reported it would be extremely to moderately beneficial to hire someone with a clinical doctorate within the AT program. Furthermore, 67% of department chairs reported they were very likely or likely to hire someone with a DAT degree. Institutions with <5000 students enrolled were more likely to hire an individual with a clinical degree (3.23 ± 0.77; $P = 0.043$). Departments that currently have faculty with a clinical doctorate were more familiar with a DAT (3.66 ± 0.64; $P = 0.015$). Master's degree granting institutions were more familiar with the educational changes occurring in AT (3.73 ± 0.52; $P = 0.009$). **Conclusions:** Department chairs recognize the DAT degree as a viable degree to teach within professional AT programs and are likely to hire an individual with a DAT degree. Future research should examine the need for the DAT degree within clinical practice settings.

Changes in Knowledge, Skills, and Integration of the Core Competencies During Post-Professional Education

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Context: Post-professional athletic training programs (PPATP) strive to improve student's knowledge, skills, and clinical integration of the post-professional core competencies (PPCCs) over time. Teaching strategies may include dedicated courses for each PPCC, assignments focused on PPCCs, and individual clinical education plans (ICEPs) to integrate PPCCs into clinical experiences. The effectiveness of such strategies is yet unknown. **Objective:** To examine changes in student's self-reported confidence in knowledge, skills, and clinical integration of the PPCCs during a PPATP. **Design:** Retrospective database analysis. **Setting:** Self-reported online clinical tracking system. **Patients or Other Participants:** 27 students (male = 6, female = 21) enrolled in 1 PPATP. **Interventions:** Self-reported confidence in knowledge, skills, and integration of the PPCCs (Evidence-Based Practice [EBP], Healthcare Informatics [HIT], Interprofessional Education and Collaboration [IPE], Patient Centered Care [PCC], Professionalism [PROF], Quality Improvement [QI]), were obtained via the AHST™ (Typhon Group, LA) online clinical tracking system from August 2015 to September 2016. Students completed an online survey at the beginning of each academic quarter, rating their level of confidence in knowledge and clinical skills for each PPCC on a 4-point Likert scale ranging from (1) "not confident at all" to (4) "extremely confident." Students also estimated the percentage of patient interactions in which they integrated each of the PPCCs during their clinical experiences. Surveys were completed for each of the 8 academic quarters of the program. **Main Outcome Measures:** Spearman correlation coefficients were calculated to assess the relationship between tenure in the program and (1) knowledge, (2) skills, and (3) integration in each of the six PPCCs. **Results:** Moderate-to-strong positive correlations were found between tenure and confidence in knowledge of EBP (r_s = .802), IPC (r_s = .898), PCC (r_s = .881), and QI (r_s = .452). Strong positive correlations were found between tenure and confidence in skills related to EBP (r_s = .643), IPC (r_s = .905), PCC (r_s = .874), and QI (r_s = .905) and between tenure and integration of EBP (r_s = .898), IPC (r_s = .976), PCC (r_s = .857), PROF (r_s = .714), and QI (r_s = .881). All correlations were significant ($p < .05$), except that between tenure and knowledge of QI ($p = .260$). Weak correlations were found for HIT (knowledge: r_s = .071; skills: r_s = .238; integration: r_s = .190) and PROF (knowledge: r_s = .168; skills: r_s = .275); all $p > .05$. **Conclusions:** Results indicate that students gained confidence in their knowledge and skills related to EBP, IPC, PCC, and QI during their tenure within the PPATP. The program utilized dedicated courses for EBP, PCC, and QI and included assignments and ICEPs focused on the PPCCs, suggesting that these teaching strategies are successful in improving student knowledge, skills, and integration of the PPCCs. Additionally, the weak correlations for HIT and program tenure may be explained by the lack of a dedicated course on HIT within the program. PPATPs should consider including dedicated courses for the PPCCs, course assignments explicit to the PPCCs, and focused ICEPs that include the PPCCs as teaching strategies to maximize integration of the PPCCs in the PPATP.

Characteristics of Positive Clinical Experiences in Post-Professional Education

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Context: Accredited post-professional athletic training programs(PPATPs) are required to include opportunities for advanced clinical practice during clinical experiences. Additionally, individualized clinical education plans(ICEPs) must be developed for each student. Clinical experiences should afford students the opportunity to have positive learning experiences, integrate classroom knowledge into clinical practice, overcome challenges, and increase their confidence. However, to date, there has been limited study of what characterizes a positive clinical experience during a PPATP. **Objective:** To examine characteristics of self-reported positive clinical experiences in PPATPs. **Design:** Retrospective database analysis. **Setting:** Self-reported online clinical tracking system. **Patients or Other Participants:** 27 students (male = 6, female = 21) enrolled in 1 PPATP. **Interventions:** Self-reported characteristics of clinical experiences related to the post-professional core competencies (PPCCs) (Evidence-Based Practice [EBP], Healthcare Informatics [HIT], Interprofessional Collaboration [IPC], Patient Centered Care [PCC], Professionalism [PROF], Quality Improvement [QI]), were obtained via the AHST™ (Typhon Group, LA) online clinical tracking system from August 2015 to September 2016. Students completed an online survey at the end of each academic quarter, rating their level of agreement with each of the following statements related to characteristics of clinical experiences for each of the PPCCs: (1) "I had positive learning experiences" (POS), (2) "I made knowledge or skill gains" (KNOW), (3) "I integrated classroom knowledge" (INT), (4) "I faced challenges" (CHAL), and (5) "I felt confident" (CONF);

agreement ranged from (1) "strongly disagree" to (4) "strongly agree." Surveys were completed for each of the 8 academic quarters of the program. **Main Outcome Measures:** Spearman correlation coefficients were calculated to assess the relationships between self-reported characteristics of clinical experiences in each of the six PPCCs. **Results:** POS were strongly correlated with KNOW (EBP: r_s = .662; HIT: r_s = .837; IPC: r_s = .822; PCC: r_s = .737; PROF: r_s = .924; QI: r_s = .591) and INT (EBP: r_s = .640; HIT: r_s = .815; IPC: r_s = .622; PCC: r_s = .639; PROF: r_s = .777; QI: r_s = .641) across all PPCCs. CONF was strongly correlated with KNOW in PCC (r_s = .635) and PROF (r_s=.622), POS in PCC (r_s = .612) and PROF (r_s = .543), and INT in IPC (r_s = .598), PCC (r_s = .644), PROF (r_s = .559), and QI (r_s = .589). All correlations were statistically significant, $p < .001$. **Conclusions:** Results indicate that positive learning experiences across all PPCCs are strongly correlated with (1) knowledge or skill gains and (2) integration of classroom knowledge into clinical practice. Student confidence during clinical experiences involving IPC, PCC, PROF, and QI are also strongly correlated with knowledge integration. These findings suggest that during clinical experiences PPATP students place a high value on the opportunity for (1) knowledge and skill gains and (2) integration of classroom knowledge. Programs should consider these characteristics when designing clinical experiences and work to ensure clinical practice sites provide opportunity for ongoing knowledge and skill gains and integration of classroom knowledge into practice. Additionally, ICEPs should include focused goals related to integration of classroom knowledge into clinical practice to further ensure positive learning experiences.

Current Preceptors Have Confusion and Uncertainty Regarding Athletic Training Degree Level Transition

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Context: Previous researchers have reported the importance of clinical education in the development of knowledge and skill during the professional education of athletic training students. Preceptors serve as clinical teachers during these important clinical experiences. With the upcoming degree level transition in athletic training education, there is a lack of research regarding the perceptions preceptors have as to how their role will change as the degree changes to the master's level. **Objective:** Explore how preceptors at bachelor's level athletic training programs anticipate their role changing when supervising professional master's level athletic training students. **Design:** Phenomenology. **Setting:** Athletic Training Programs. **Patients or Other Participants:** 5 preceptors (3 males, 2 females; 39 + 11 years old; 13.0 + 11 years experience, 3 from secondary school setting, 2 from collegiate setting) associated with 5 different professional bachelor's level athletic training programs participated. **Data Collection and Analysis:** Participants completed a semistructured interview including introductory questions (e.g., experiences as a clinical educator), behavioral questions (e.g., interpersonal skills, critical thinking, clinical decision-making), supervisory questions (e.g., supervisory style, mentorship), and professional development questions (e.g., needs for development). Interviews were audio recorded, transcribed verbatim and analyzed inductively using an interpretative coding method. Data were initially read by two researchers for understanding and then was coded with meaning units. Trustworthiness was established through data analyst triangulation, member checks, and peer review. Group responses were solicited until data saturation occurred. **Results:** Overall, participants expressed confusion and uncertainty regarding the degree level transition from the bachelor's to master's level. Regardless of the degree level, participants expressed an emphasis on the need for clinical experiences to develop readiness for clinical practice. Two major themes emerged, *expectations of students* and *expectations of preceptors*. Expectations of students included 1) characteristics participants believed master's level students will possess prior to enrolling in a professional program, 2) capacity for critical thinking and clinical decision-making, and 3) athletic training experiences. Expectations of preceptors included 1) participant's perceptions regarding how their role as a preceptor will change, including communication, 2) mentorship, 3) providing supervised autonomy, and 4) professional development needs. **Conclusions:** Current bachelor's level preceptors perceive similarities (i.e., emphasis on providing students with quality clinical experiences to supplement classroom learning, need for mentoring novice students) yet some differences (i.e., master's students will be more mature, master's students will possess the ability to synthesize classroom knowledge in patient care, and make decision regarding patient care more quickly) regarding their role after the degree level transition. Professional level programs should provide training during preceptor development on the degree level transition and programmatic expectations of preceptors after transitioning to the master's level.

The Perception of Trust Between Athletic Trainers and Musical Performing Artists

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Context: Trust is an attribute that gives medical relationships intrinsic value and increases the chance of a successful patient-clinician relationship. Many factors determine trust between patient and clinician including trustworthiness, clinical competence, benevolence, approachability, and predictability. Overall, a patient's trust is based on experience and the nature of relationship they have with a certain provider. Similar to a traditional athlete, performing artists have unique needs and face strenuous physical and mental demands. Musical performing artists devote an abundance of time to practicing their instrument or craft and caring for their body as an essential means of performance. Injury risk remains high due to complexity of physical requirements and expectations; though, the performing arts stands as an underserved population with decreased access to resources and medical care comparatively to sport athletes. Since ATs are new to this setting, it is essential for the profession to understand these demands in order to provide the best care and build a solid foundation for trust within the patient-athletic trainer relationship. Currently, one work has focused on patient trust in the athletic training setting and it does not evaluate the performing arts. Though trust has been evaluated in other professions such as nursing, psychotherapy, and general medicine, it is difficult to translate results to athletic training due to differences in scope of practice, working circumstances, and populations reached. This represents a critical knowledge gap for the profession since it is reasonable to presume, like any other healthcare profession, that the relationship between athletic trainer and patient will be established and influenced by trust. **Objective:** The specific aim of this study was to critically evaluate the amount of trust performing artists, specifically drum corps members, had in their athletic trainer. Through qualitative measures, it was hypothesized that this study would determine the basic level of trust between musical performing artists and athletic trainers as well as how it affected the patient-clinician relationship. These research questions were answered: 1. What factors influence trust between the performer and athletic trainer? 2. To what extent does trust influence the relationship between drum corps members and athletic trainers? **Design:** The study included semi-structured interviews based on the principles of Grounded Theory. Specific to this research, the mechanism of trust is based on the rational choice model rooted in the impression of social exchange. This model suggests that people are motivated to maximize personal gains and minimize personal losses in social interaction by reacting to other individuals from a self-interested perspective. **Setting:** The environmental setting participants were selected from is a comprehensive performing arts activity for young adults primarily taking place throughout the summer months, although, the research was implemented in the off-season and could be replicated among other performing arts populations. A virtual research setting was used (via Skype), therefore, allowing the research methods to be transferable and easily implemented. **Patients or Other Participants:** Participants were obtained from four different drum and bugle corps (n=12; 3 per group; 6 female, 6 male). Each participant was required to classify as a current World Class Drum Corps International member between the ages of 16-22 years old (avg. age = 19.6). They must have had past interaction with an athletic trainer in their respective performing arts group. First year members of the drum corps were excluded due to their lack of interaction with an athletic trainer in the previous season. The researchers contacted the Head Athletic Trainer of each performing arts group to recruit participants via word of mouth and e-mail. Theoretical sampling was used by blindly drawing participants from the lists provided by the Head Athletic Trainers. As established in the literature, a sample size of 12 was recommended for saturation to occur. To ensure saturation was met, we continued with interviews until no new information was identified. **Data Collection and Analysis:** Interview questions were written and formulated based on past trust instruments including the Patient-AT Trust Instrument. The semi-structured interview protocol was piloted to drum corps members/staff and refined based on the results. Researchers conducted the interviews using a semi-structured interview protocol. The protocol included pre-determined questions to ensure consistency of data collection followed by additional questions as the researcher deemed necessary. Interviews were conducted via Skype in a private, quiet space and lasted approximately one hour. Prior to the interview, the participant completed the informed consent document. A digital voice recorder was used for clarity and for transcription purposes. Interviews were transcribed verbatim and analyzed using an inductive content analysis. Coding of the transcripts, using Atlas.ti (Berlin, Germany), was completed by assigning labels of specific units of data that conveyed meaning to the research purpose. Data was then organized into categories and then identified through emerging themes. To ensure trustworthiness, triangulation between each member of the research team was utilized by reaching a consensus related to emergent findings. Member checks were conducted by having 1/3 of the participants examine their transcripts for accuracy. In addition, an external auditor verified emergent themes and factors. Negative case analyses were also conducted. **Results:** Subject responses were separated into 21 codes and then were identified through 6 emergent themes. The subjects uniamously reached saturation in their responses. These themes indicate factors that promote and hinder the patient-clinician relationship in the drum and bugle corps setting. The

most prominent codes were as follows: accessibility, clinical competence, dependability, comfort, and having a plan of action. The themes (availability, personality traits, advocacy, interaction, professional traits, credibility) derived from these codes characterized participants' perception of trust in their athletic trainer. **Conclusions:** Trust plays a role in determining patient rapport, compliance, and timely return-to-play via patient clinician relationship in the performing arts setting. All subjects perceived trust as an important aspect (regardless of positive or negative clinician interactions) in achieving ideal healthcare as a musical performing artist. Further research is needed to verify whether factors established within this study transcend into other areas of performing arts and across Drum Corps International as an entity.

Undergraduate Poster Award Finalist

Attractors to Faculty Positions Within Higher Education Institutions for Women in Athletic Training

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Context: Career choice is influenced by a combination of psychological, sociological, socioeconomical and personality variables. Attraction to a career is often viewed as anticipatory whereby a person attempts to informally learn about the roles, values, and expectations of that career. For athletic training, a major attractor has been the connection to sport. Scholars have focused on identifying initial attractors to education programs as well clinical employment settings. However, little is understood about why an athletic trainer pursues a role in higher education, specifically women athletic trainers. **Objective:** Gain a better understanding of what factors influenced women athletic trainers to pursue a career as a faculty member. Furthermore, it has been postulated that women select employment settings that reflect a 'family-friendly' mindset therefore we additionally focused on attractive attributes in the woman's current position in higher education. **Design:** Qualitative Phenomenology. **Setting:** Commission on Accreditation of Athletic Training Education (CAATE) accredited programs **Patients or Other Participants:** 16 women faculty members with 11 (average) years of experience teaching and 14 (average) years of experience as certified athletic trainers. We sought the experiences of women with kids (n = 8) and without them (n = 8). **Data Collection and Analysis:** One-on-one phone interviews, digitally recorded and transcribed, were completed with each woman meeting our inclusion criteria. Data was analyzed following the interpretative phenomenological approach. Credibility was established through pilot testing, peer review, and researcher triangulation. **Results:** Three themes emerged regarding the primary reasons women athletic trainers in higher education were attracted to their positions. The *first attractor* was a connection between the women's employment goals and the tenents of higher, teaching and research. The multiple roles of a faculty member provided enjoyment and fulfillment to the participants while allowing them to interact with students and impact the future of the profession. The *second attractor* was the flexible and accommodating schedule of a faculty member, in which the women were able to shape and fit their individual needs. In the *third attractor*, logistics and location, participants indicated their current positions enabled them to live in a place that was desirable or allowed for their spouse to maintain employment. **Conclusions:** Pursuing a faculty role in higher education for women athletic trainers is stimulated by personal and organizational factors. Women athletic trainers are attracted to positions in higher education due to their professional goals of teaching and research, in which they find enjoyment as well as the flexibility of the schedule and the locations of positions they have found. The chance to have a flexible work schedule is a reason for women to pursue roles in higher education. Providing women athletic trainers opportunities to teach and interact with students may increase their enjoyment and fulfillment in their position.

Electrical Point Stimulation on Myofascial Trigger Points in the Upper Back and Neck Muscles

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Context: Electrical point stimulation (EPS) is suggested to decrease MTrP (myofascial trigger point) pain without influencing sensitivity immediately post-treatment. In clinical practice, it may be difficult to assess the efficacy of a treatment when measures are taken immediately after. **Objective:** Determine if EPS decreases pain perception or pressure pain sensitivity in the and upper back and neck muscles over time. **Design:** Randomized controlled study. **Setting:** Laboratory **Patients or Other Participants:** Fifteen subjects (9 males and 6 females; age: 21.5 ± 31.06 years, height: 173.57 ± 9.44, mass: 74.12 ± 8.64 kg) with MTrPs in their dominant trapezius, latissimus dorsi, supraspinatus, and infraspinatus volunteered. **Interventions:** Subjects reported to a laboratory on 6 days over two weeks and were randomly assigned to a treatment (EPS), placebo (fake EPS), or control (nothing) group. We identified MTrPs in the same areas within the trapezius, latissimus dorsi, supraspinatus, and infraspinatus muscles using an ohm meter in our EPS unit. Once identified, a pressure algometer was then applied to each MTrP 3 times with a 20 second rest between each measure to assess sensitivity. Immediately following, subjects receiving EPS were treated for 3 minutes (pulse rate = 4.0 Hz; negative polarity) with intensity adjusted to comfort. Subjects in the placebo group received the same procedures except we did not increase intensity. Control group subjects also reported to the lab on 6 days where measures were taken at the same time intervals. Pressure pain sensitivity and pain perception were recorded immediately post-treatment and 10 minutes' post-treatment. **Main Outcome Measures:** Pressure pain sensitivity and pain perception. Descriptive statistics (mean ± SD) were calculated; repeated measures analysis of variance with Tukey-Kramer post-hoc tests were used to identify differences ($\alpha = 0.05$) **Results:** A significant treatment by time interaction for pain at the trapezius ($F_{4,24} = 14.29$, $P = .001$), supraspinatus ($F_{4,24} = 11.08$, $P = .001$), and infraspinatus ($F_{4,24} = 4.07$, $P = .01$) occurred with EPS. Pain in these muscles decreased immediately post-treatment and 10 minutes' post-treatment with EPS ($P < .05$). At the latissimus dorsi, no significant interaction was observed ($F_{4,24} = .34$, $P = .85$). Pain with the placebo, decreased post-treatment but not at 10 minutes' post-treatment at the trapezius and supraspinatus ($P > .05$) with no differences occurring in the latissimus dorsi or infraspinatus ($P > .05$). At 10 minutes' post-treatment, pain at the trapezius and supraspinatus were less than the placebo and control ($P < .05$). Control group did not change over time ($P > .05$). EPS did not influence pressure pain: trapezius ($F_{2,12} = 3.29$, $P = .07$), latissimus dorsi ($F_{2,12} = 2.72$, $P = .11$), supraspinatus ($F_{2,12} = 2.09$, $P = .17$), infraspinatus ($F_{2,12} = 2.14$, $P = .16$). There was however a significant interaction between treatment and day for the infraspinatus ($F_{10,60} = 2.21$, $P = .03$). Pressure sensitivity with EPS on day 5 and 6 were greater than placebo ($P < .05$). **Conclusions:** EPS decreases pain in select upper neck and back muscles for up to 10 minutes' post-treatment. For individuals who experience MTrP pain, clinicians should utilize EPS.

Effects of Neuromuscular Electrical Stimulation Frequency on Markers of Skeletal Muscle Growth in Humans

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Context: Neuromuscular electrical stimulation (NMES) is commonly used by athletic trainers to increase muscle mass and strength. However, the effects of NMES on muscle growth are not clear and no human studies have compared the response of cellular markers of muscle growth between low-frequency (LF-) and high-frequency (HF-) NMES. **Objective:** To determine the anabolic and neurotrophic skeletal muscle response to an acute bout of LF- and HF-NMES. Design: Pre-test – post-test crossover experimental design. **Design:** Pre-test – post-test crossover experimental design. **Setting:** Research laboratory. **Patients or Other Participants:** Ten young healthy non-strength trained volunteers (men: $n = 5$; women: $n = 5$; mean age: 24.8 ± 1.2 years) completed the study. **Interventions:** Participants received an acute bout of LF- (20 Hz) and HF- (60 Hz) NMES on different days and in random order. Muscle biopsies were obtained from the *vastus lateralis* muscle before and after the 60-min NMES treatment. An isometric dynamometer measured force output during NMES and stimulation intensity was adjusted to maintain force output at 15% of maximal strength. Skeletal muscle anabolic signaling was analyzed by Western Blot and brain-derived neurotrophic factor (BDNF) concentration was analyzed by Milliplex assay. Each dependent variable was analyzed using repeated measures ANOVA (Treatment Condition: Pre-NMES, LF-NMES, HF-NMES). **Main Outcome Measures:** Phosphorylation of

key anabolic signaling proteins (mammalian target of rapamycin (mTOR), p70-S6 Kinase 1 (S6K1), eukaryotic initiation factor 4E binding protein 1 (4EBP1)) and BDNF concentration of skeletal muscle. **Results:** There was a main effect for phosphorylation of mTOR (Pre-NMES: 0.45 ± 0.05; LF-NMES: 0.72 ± 0.09; HF-NMES: 0.96 ± 0.07 arbitrary units (AU); $P < 0.001$). Phosphorylation of mTOR was higher for LF-NMES compared to Pre-NMES ($P = 0.029$) and HF-NMES was higher than Pre-NMES ($P < 0.001$) and LF-NMES ($P = 0.026$). There was also a main effect for S6K1 phosphorylation (Pre-NMES: 0.82 ± 0.10, LF-NMES: 1.57 ± 0.42, HF-NMES: 2.85 ± 0.46 AU; $P = 0.001$). Phosphorylation of S6K1 was not different between Pre-NMES and LF-NMES ($P = 0.20$) or LF- and HF-NMES ($P = 0.05$), but HF-NMES was higher than Pre-NMES ($P = 0.003$). There were no differences between treatment conditions for 4EBP1 phosphorylation (Pre-NMES: 1.13 ± 0.12, LF-NMES: 1.26 ± 0.27, HF-NMES: 1.23 ± 0.28 AU; $P = 0.87$). BDNF concentration was not different between conditions (Pre-NMES: 8.0 ± 3.8, LF-NMES: 15.0 ± 13.1, HF-NMES: 21.5 ± 28.0 pg/ml; $P > 0.05$). **Conclusions:** An acute bout of LF- and HF-NMES upregulated anabolic signaling with HF-NMES producing a greater anabolic response compared to LF-NMES. BDNF was not significantly affected by an acute bout of NMES; however, there was a trend toward upregulation. HF-NMES may be more effective than LF-NMES for stimulating muscle hypertrophy in young healthy adults.

The Effect of Multipath Current Distribution on NMES-Induced Torque Production

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Context: The effectiveness of neuromuscular electrical stimulation (NMES) treatments is primarily dependent on peak torque production of the NMES-induced contractions. Previous studies have reported greater NMES-induced peak torque production when using a novel multipath NMES (m-NMES) device, relative to a conventional NMES (c-NMES) device. The m-NMES stimulator employs a multipath current distribution method that is marketed as having the potential to positively impact NMES outcome measures, and the results of previous studies suggest that the m-NMES device may be advantageous. However, due to systematic differences in the electrode configurations used across conditions of the previous studies, the mechanisms by which m-NMES outperformed c-NMES remain unclear. To better understand the influence of the novel multipath current distribution method on NMES-induced peak torque, a comparison using similar electrode configurations was needed. **Objective:** To compare peak torque production during NMES-induced contractions of the quadriceps while using m-NMES and c-NMES devices, and similar electrode configurations. We hypothesized that peak torque production would be significantly greater while using the m-NMES device. **Design:** Crossover study. **Setting:** Research laboratory. **Patients or Other Participants:** A convenience sample of 21 healthy recreationally active males (23.9±5.1yr, 175.1±7.4cm, 78.1±11.7kg, 25.3±2.6kg/m^2) completed the study. **Interventions:** After completing a previous study in our laboratory, which served as four familiarization sessions during the current study, participants performed NMES-induced isometric quadriceps contractions on two separate occasions using a c-NMES or m-NMES device. A Kneehab® XP stimulator (Theragen LLC, Leesburg, VA) distributed a biphasic current across multiple pathways within two channels. A Sonicator® Plus 940 stimulator (Mettler Electronics® Corp., Anaheim, CA) distributed a similar biphasic current within two channels via conventional fixed pathways. During each condition, four electrodes were affixed over the superficial quadriceps using a similar configuration. Participants self-selected a maximum comfortable amplitude prior to performing each condition. **Main Outcome Measures:** Peak torque during the NMES-induced isometric quadriceps contractions was measured with an isokinetic dynamometer and normalized to participant body mass. A dependent *t*-test was used to analyze the data. **Results:** No significant difference (t_{20}=1.397, P=0.089, d=0.282) in normalized NMES-induced peak torque was observed between the m-NMES (1.4±0.6Nm/kg) and c-NMES (1.3±0.5Nm/kg) conditions. **Conclusions:** Based on our results, it does not appear that the novel multipath current distribution method positively impacts NMES-induced peak torque production. Previous studies have observed greater peak torque production when using the m-NMES device. We believe that it is likely that a systematic difference in electrode configurations was a contributing factor to the results of earlier studies, since we did not observe a significant difference while using similar electrode configurations across conditions.

The Effect of Low-Level Laser Therapy on Delayed Onset Muscle Soreness When Delivered Pre- and Post-Eccentric Exercise

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Context: Delayed onset muscle soreness (DOMS) is a set of symptoms including muscle soreness, decreased muscle strength, and decreased function that present 24-48 hours after eccentric or unaccustomed-to exercise. Clinically, low-level laser therapy (LLLT) is being used to attenuate DOMS symptoms. **Objective:** The purpose of this study was to determine the effectiveness of LLLT for the management of DOMS when delivered pre- and post-eccentric exercise. **Design:** Double-blind randomized control. **Setting:** Controlled laboratory. **Patients or Other Participants:** Twenty-seven healthy male volunteers were randomly assigned into one of three groups (LLLT = 10, height = 181.1 ± 6.9 cm, weight = 91.4 ± 2.3 kg, age = 23.4 ± 4.4 yr; Sham = 8, height = 177.3 ± 5.8 cm, weight = 77.4 ± 7.2 kg, age = 23.4 ± 6.9 yr; Control = 9, height = 177.3 ± 5.8 cm, weight = 77.7 ± 8.2 kg, age = 20.7 ± 2.2 yr). **Interventions:** All subjects received their assigned treatment first. Following the pre-exercise treatment, subjects performed an eccentric exercise protocol of their elbow flexors. Immediately following the eccentric exercise subjects received a second treatment intervention. Subjects returned 24-hours post-exercise protocol and received a third treatment. The LLLT group received active laser treatment at each treatment time. The Sham group did not receive active laser however LED lights were turned on during each treatment. The Control group did not receive any treatment. **Main Outcome Measures:** Pain, isometric muscle strength, and upper extremity function were assessed pre-, 24-hours post, and 48-hours post eccentric exercise. Pain was assessed using a visual analog scale. Isometric muscle strength was assessed by performing mid-range isometric contractions of the elbow flexors. Upper extremity function was assessed using a custom made speed and accuracy reach board. For each outcome, 3x3 ANOVAs were conducted, alpha was set *a* priori at $P < .05$. **Results:** There was no significant group by time interactions for pain ($F(4, 48) = .33$, $P = .85$), isometric muscle strength ($F(4, 48) = .13$, $P = .97$), or upper extremity function ($F(4, 48) = 1.35$, $P = .27$). There was a significant time main effect for pain ($F(2, 48) = 53.40$, $P < .001$). All subjects had a significant increase in pain from pre- to 24-hours post eccentric exercise. There was also a significant time main effect for muscle strength ($F(2, 48) = 24.40$, $P < .001$). There was a significant decrease in pain from pre- to 24-hours post eccentric exercise. There was no significant time main effect for function ($F(2, 48) = .61$, $P = .55$. **Conclusions:** Although LLLT was found ineffective for treating those symptoms of DOMS at our chosen parameters, previous literature has shown that LLLT has promising effects on attenuating symptoms of DOMS.

Athletes' Perceived Confidence to Return to Sport Pre- and Post-Sequential Pulse Compression: A Practice-Based Assessment

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Context: Patient centered care is at the core of evidence-based medicine and is comprised of three components: best available research, clinician expertise, and patient values. Each of these components are essential to keeping the patient at the center of the care model. One area that is often overlooked in interventions research is patient values. Therapeutic interventions aim to complement the body's natural healing processes and decrease time-loss due to injury. Interventions are especially helpful to reduce time needed to recover from physical activity. One such intervention, Sequential Pulse Compression (SPC), has support for its use via traditional research; however, no literature exists which examines a patient's perception of its effectiveness. **Objective:** To determine the change in perceived confidence to return to sport before and after treatment with SPC when utilized in clinical practice. **Design:** Practice-based Research. **Setting:** University Athletic Training Room. **Patients or Other Participants:** Student athletes (male = 137, female = 88) from nine sports teams who were either recommended for the intervention or requested the intervention. **Interventions:** We utilized SPC applied to the leg(s), arm(s) and/or hips at clinician recommended treatment parameters. Each patient who underwent a treatment with SPC was asked to complete a questionnaire containing four demographic questions and the Injury-Psychological Readiness to Return to Sport (I-PRRS) scale. The demographic questions purposed to identify what sport in which the patient competes in, the gender with which the patient identifies and the body part which was being treated. The

six I-PRRS questions were answered pre-intervention and post-intervention on a digital 100mm visual analog scale. Patients completed the questionnaire on a personal electronic device via an anonymous link or QR code. **Main Outcome Measures:** The independent variable was time (pre-and post-treatment) and dependent variables were each of the six items on the I-PRRS scale. Each item was analyzed using a dependent t-test. **Results:** We found a significant difference in overall confidence to play ($t_{(224)} = 2.07$; $p = 0.04$, mean difference = 3.09 ± 22.43; ES = 4.47); confidence to play without pain ($t_{(224)} = 6.23$; $p \leq 0.01$, mean difference = 11.84 ± 28.50; ES = 5.52); confidence to give 100% ($t_{(224)} = 4.63$; $p \leq 0.01$, mean difference = 10.50 ± 34.00; ES = 8.04); confidence to not concentrate on the injury ($t_{(224)} = 7.50$; $p \leq 0.01$, mean difference = 17.55 ± 35.10; ES = 7.79); confidence in the injured body part to handle the demands of the situation ($t_{(224)} = 7.98$; $p \leq 0.01$, mean difference = 17.13 ± 32.20; ES = 6.97); confidence in my skill level/ability ($t_{(224)} = 7.51$; $p \leq 0.01$, mean difference = 15.75 ± 31.44; ES = 6.57). **Conclusions:** These data suggest that a single treatment of SPC is effective in improving a patient's perceived confidence to participate in his or her sport. These results, combined with systematic evidence and clinician expertise support the use of SPC in clinical practice.

Pain Reduction and Increased Function in Patients With Low Back Pain Treated with a Low Level Laser: A Stratified Randomized, Blinded, Placebo Controlled Trial

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Context: Limited research exists on patients with low back pain treated with a neodymium yttrium aluminum garnet (NdYAG) laser (1064 nm). This study is an innovative approach on low back pain treatment of exercise and laser separately and conjunctively. **Objective:** The purpose of this study was to investigate the effect of LLLT (Low Level Laser Treatment) on pain reduction and daily living activities among low back pain patients when compared to traditional exercises. **Design:** Highly controlled quasi-experimental study. **Setting:** Two physical therapy clinics. **Patients or Other Participants:** The sample included 43 patients (33 females, 10 males) which volunteered for random stratification into treatment groups based on injury types (disc herniation, disc degeneration, and strain/sprain pathology). Patients' exhibited height = 168.3 ± 10.5 cm; mass = 74.0 ± 15.6 kg; body fat = 29.9% ± 7.6, age = 50.2 ± 13.4 years old, with pain duration = 67.3 ± 101.7 months. **Interventions:** With similar pathologies across treatment interventions, the interventions included NdYAG laser irradiation of 36 J/cm^2 energy density delivered to 7 locations in the lumbar area in two active (with exercise and no exercise) and one placebo (with exercise) groups. Repeat questionnaires (McGill Pain Questionnaire and Oswestry Low Back Pain Disability Questionnaire) were administered after 12 sessions over 4-8 weeks. A double-blinded approach was employed. A repeated measures analysis was administered to assess differences between and within groups. **Main Outcome Measures:** Treatment groups (exercise with placebo laser, exercise and laser, and laser only) affect on pain and function scales was used to assess differences based on repeated measures doubly multivariate analysis of variance (MANOVA). **Results:** Treatment type did not significantly affect the outcome scores of pain and function, F (4, 78) = 2.18, $p > .05$. However, the main effect of time was statistically significant, the participants improved on pain and function, F (2, 39) = 33.82, $p < .001$, with omega-squared of .276. However, the interaction between time and treatment type was not statistically significant, F (4, 78) = 1.10 $p > .05$. Mean differences on pain were 21.38 ± 22.53, 27.07 ± 18.25 and 20.01 ± 20.80 and for function 22.84 ± 17.28, 19.20 ± 14.96, and 14.68 ± 13.96 for exercise, combination, and laser only, respectively. The results of this study indicated that the combination of exercise and LLLT markedly reduced pain more than other groups; however, this change did not reach stastical significance. **Conclusions:** All patients improved on pain and function scores after treatment was administered. Treatment was attributed to 28% of the improvement in low back pain and function. Therefore, all these treatment types are reasonable and have similar positive effects. Rehabilitation should begin to integrate laser treatment when pain negates the opportunity to exercise.

The Effects of ThermoStim Instrument Assisted Soft Tissue Mobilization and Superficial Heat on Range of Motion of the Hamstrings and Perceived Patient Comfort

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Context: The Dynatronics ThermoStim probe, introduced in 2012, provides simultaneous superficial heat, cold, electrical stimulation, and instrument assisted soft tissue mobilization (IASTM); one pilot study has been conducted using the ThermoStim probe which utilized superficial heat, electrical stimulation, IASTM, and stretching exercises with light therapy on patients with plantar fasciitis. Due to the number of modalities used, it is unknown which one impacted the increase in foot function; it is also unknown if adding superficial heat during the IASTM treatment will increase range of motion more than an IASTM treatment alone. **Objective:** To determine if range of motion of the hamstrings can be increased utilizing IASTM, and whether superficial heat creates an additional increase in range of motion and perceived patient comfort. **Design:** We used a pre-/post-test design for range of motion increases and perceived patient comfort. The independent variable was the inclusion of a superficial heat setting of 5 on the ThermoStim probe. The dependent variable was range of motion of the hamstrings and perceived patient comfort. **Setting:** University Research Laboratory. **Patients or Other Participants:** A sample of 30 healthy, college-aged individuals volunteered (15 females, 15 males; 20.27 ± 1.015 years). All had tight hamstrings, defined by less than 70° of passive knee extension when the hip was flexed to 90°. **Interventions:** Both groups received the same ten minute IASTM treatment on the left hamstring two times, 72 hours apart. The experimental group also received simultaneous superficial heat via the ThermoStim probe during both treatments. **Main Outcome Measures:** The hamstring range of motion was measured prior to and after the intervention. Participants also completed a survey post-intervention regarding perceived patient comfort during the treatment. **Results:** A significant increase in range of motion existed for all participants for both treatments. For the first treatment, range of motion increased from 52.23 ± 10.45° to 60.39 ± 9.58° [$t(29) = 8.365$, $p < 0.01$], and from 55.58 ± 7.31° to 66.23 ± 6.77° [$t(29) = 14.652$, $p < 0.01$] for the second treatment. However, no significant differences in range of motion existed between groups for either treatment. Gender had no influence on the results. The addition of superficial heat also showed no significant difference between groups for perceived patient comfort. **Conclusions:** Delivering IASTM through the ThermoStim probe created statistically and clinically significant range of motion increases in the hamstrings. Though superficial heat had no effect on the results, friction from the treatment could have created warmth similar to the superficial heat setting on the ThermoStim probe. Participants rated comfort from very uncomfortable to very comfortable, but all stated they would request the treatment again due to the increased flexibility felt post-treatment. Future research should examine the effectiveness of range of motion increases on unhealthy tissues and more diverse populations.

The Effects of Myofascial Release on Ankle Range of Motion and Hamstring Flexibility

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Context: Myofascial release is often used to relieve tension within a musculotendinous unit. Currently, there are no existing techniques that focus on specific myofascial continuities. The superior back line is a myofascial continuity that originates on the frontal bone, passes posteriorly over the musculature and inserts on the plantar surface of the distal phalanges. It is possible that, by releasing one area of this continuity, motion may be improved at other areas along it. **Objective:** To determine the acute effects of plantar fascia mobilization (PFM) on dorsiflexion range of motion (DROM) and hamstring flexibility. **Design:** Randomized single-blind cross-over design. **Setting:** Research laboratory. **Patients or Other Participants:** Twenty-one healthy recreationally active males and females (age = 20.4 ± 0.97 years, height = 166.6 ± 9.1 cm, mass = 69.4 ± 15.7 kg) who were not suffering from any lower body injury or condition affecting lower extremity ROM. **Interventions:** Each participant reported to the facility for two sessions separated by a period of at least one week. At each session, the participants received a moist heat pack to the plantar aspect to the non-dominant foot for 10-min. The participants then completed one of two treatment conditions, PFM or control. The PFM condition consisted of PFM using a golf ball. While in a seated position, the foot was placed on a platform so that the golf ball was under the non-dominant medial calcaneal tubercle and held there for 45-s. The medial longitudinal arch was then rolled over the ball until it reached the first metatarsal head and held for 15-s. It was then rolled back to the medial plantar tubercle and held for 15-s. This was repeated for each consecutive metatarsal. The subject then stood on the platform with the distal great toe positioned over a stationary golf ball which maintained it in hyperextension while the uninvolved leg was stepped forward for 15-s. This was done for each toe. The control condition consisted of seated rest for 5-min. **Main Outcome Measures:** DROM and hamstring flexibility were assed immediately prior to and immediately following treatment. DROM was assessed using the weight-bearing lunge test. Hamstring flexibility was assessed using a standard sit-and-reach test. **Results:** The two-factor mixed analysis of variance revealed a significant Test main effect ($F_{1,10}$ = .083, p = .779) for DROM, as ROM was greater at posttest (45.76 ± 5.92°) as compared to pretest (44.90 ± 6.10°). However, the treatment had no effect, as a significant Condition x Test interaction ($F_{1,20}$ = .016, p = .900) was not observed. PFM also had no effect on hamstring flexibility, as a significant Condition x Test interaction ($F_{2,10}$ = .067, p = .799) was not observed. **Conclusions:** PFM did not have an acute effect on DROM or hamstring flexibility. It is possible that this type of treatment might require a longer session or multiple sessions and a more chronic effect. Future research should address repeated treatments.

The Acute Effects of Different Foam Rolling Timing Durations on Hamstring Flexibility

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Context: The use of a foam roller is growing in popularity as a pre-participation warm-up method. Limited available research indicates that foam rolling has the ability to increase flexibility and range of motion (ROM), without affecting performance measures, such as power output. Current research, however, lacks an accepted foam roller intervention timing duration prior to activity in order to increase ROM. **Objective:** To evaluate hamstring flexibility changes following a single foam rolling bout, performed for durations of 30-seconds or 2-minutes, compared to controls. **Design:** Single blinded, randomized study. **Setting:** Laboratory **Patients or Other Participants:** Forty-two healthy, physically active individuals (females = 30, age = 20.4 ± 3.0 years, height = 153.2 ± 7.6 cm, mass = 64.2 ± 15.3 kg) volunteered. Participants were required to be familiar with foam rolling and have passive hip flexion ROM <130°. **Interventions:** Participants reported for two testing sessions separated by one week. On day one, baseline hamstring flexibility measurements were taken and the proposed foam rolling method was introduced. Subsequently, participants were evenly distributed into one of three groups (30-seconds, 2-minutes, or control) by gender. Day two data collection consisted of: pre-warm-up flexibility, 5-minute self-selected pace walking warm-up, post-warm-up flexibility, assigned intervention, immediately post-intervention flexibility, 10-minutes post-intervention flexibility. During the assigned intervention, participants in either foam rolling group rolled the length of the hamstrings in the sagittal plane from the

ischial tuberosity to popliteal fossa at a metronome cadence of 40 Hz. Those in the control group were instructed to remain stationary in a long seated position for two minutes. During all flexibility measurements, participants were taken into passive hip flexion ROM by an investigator until the participant verbalized a "perceived maximum stretch." A separate, single investigator took all goniometric measurements. **Main Outcome Measures:** Variables of interest were goniometric hip flexion ROM measurements at pre-warm-up, immediately post-warm-up, immediately post-intervention, and 10-minutes post-intervention. A 3 x 5 mixed model factorial ANOVA was performed for each group against time. **Results:** We found no statistically significant interaction effect within subjects for time and intervention ($p = 0.788$), indicating no differences between changes in each of the groups' hamstring flexibility across time [Day 2 Baseline (30-Seconds: 89.86 ± 16.84°; 2-Minutes: 92.36 ± 12.17°; Control: 91.71 ± 10.14°), Post Warm-Up (30-Seconds: 93.93 ± 17.76°; 2-Minutes: 94.57 ± 9.21°; Control: 96.21 ± 11.81°), Post Intervention (30-Seconds: 96.21 ± 17.88°; 2-Minutes: 99.43 ± 11.39°; Control: 96.71 ± 9.97°), 10-Minutes Post Intervention (30-Seconds: 95.00 ± 16.88°; 2-Minutes: 94.86 ± 11.01°; Control: 96.14 ± 11.99°)]. For all groups combined, there was a significant increase ($p < 0.01$) in hamstring ROM from baseline (91.31 ± 13.06°) to post warm-up (94.91 ± 13.11°), immediately post warm-up (97.45 ± 13.27°), and ten minutes post-intervention (95.33 ± 13.21°). Further analysis at each individual time point supported there were no significant differences between groups at all five time points ($p > 0.05$). **Conclusions:** A single bout of foam rolling, for either 30-seconds or 2-minutes, is not an effective tool to increase hamstring flexibility compared to a 5-minute walking warm-up alone.

The Effect of Deep Oscillation Therapy on Hamstring Flexibility

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Context: Hamstring inflexibility can lead to acute and chronic conditions such as low back pain and hamstring strains. Hamstring inflexibility is typically treated using therapeutic massage, stretching, and soft tissue mobilization. An alternative intervention is deep oscillation therapy (DOT), or HIVAMAT®, an electrostatic manual therapy requiring minimal pressure. Currently, evidence is lacking to support DOT's effectiveness to improve flexibility. **Objective:** To explore the effectiveness of DOT to improve patient and clinician-rated outcomes for hamstring flexibility. **Design:** Randomized single-cohort. **Setting:** Research laboratory. **Patients or Other Participants:** Twenty-nine healthy, physically-active (self-reported activity of a minimum 200 minutes per week) individuals (males = 14, females = 15, height = 172.93 ± 9.74 cm, mass = 76.42 ± 14.48 kg, age = 22.86 ± 2.29 years) volunteered for this study. **Interventions:** All participants received a single session of DOT with randomization of the participant's leg that would receive the intervention. The DOT intervention parameters included a 1:1 mode and 70-80% dosage. The researcher donned gloves and applied talcum powder to the intervention sites while connected through an electrical current. The intervention began by stimulating the lymphatic channels from the cisterna chyli (1min.), to the inguinal lymph node (1min.), and finishing with the popliteal lymph node (1min.) each at a frequency of 150 Hz. The frequency was changed to 64 Hz for 20 minutes during application to the hamstring muscle group. Finally, the participant was treated distal to the inguinal node at 25 Hz (5min.). Total intervention time was 28 minutes. Hamstring flexibility was assessed using a passive straight leg raise (PSLR) for hip flexion using a digital inclinometer. Patient-reported outcomes were evaluated using the Globating Rating of Change (GRC). **Main Outcome Measures:** The independent variable was time (pre and post). The dependent variables included PSLR (mean degrees pre- and post-intervention), and the GRC (-7 points(very great deal worse) to 7 points(great deal worse)), and the participant's perceptions of the intervention (1 point(strongly disagree) to 7 points(strongly agree)). Statistical analyses included a dependent t-test and a Pearson correlation. **Results:** PSLR significantly improved post-DOT (95% CI: 4.48-7.85%, $p < 0.001$) with a mean difference of 6.17 ± 4.42°. The average range of motion for participants for pre-DOT was 75.43 ± 21.82° with post-DOT range of motion measuring 81.60 ± 23.17°. The average percent increase for all participants was 8.53% for measures from pre- to post-DOT. Participants noted feeling between "somewhat" to "moderately better" (3.17 ± 1.56) post-DOT on the GRC. A significant moderate positive correlation was identified ($r = 0.439$, $p = 0.017$) amongst all participants between the GRC and the mean change score of hamstring flexibility. Participants believed that the intervention improved their hamstring flexibility (5.41 ± 1.02 points), would be a helpful in injury prevention (4.90 ± 1.21), and was relaxing (6.21 ± 0.86). **Conclusions:** This study revealed that DOT is an effective intervention to increase hamstring flexibility when measured using patient- and clinician-reported outcome measures.

The Immediate Effects of Hold-Relax Stretching on Hamstring Flexibility Compared to Control

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Context: Previous studies have identified that hamstring flexibility is crucial in minimizing hamstring strains and other lower extremity injuries. Healthcare providers utilize a variety of methods to increase hamstring flexibility. **Objective:** To determine if a single treatment Proprioceptive Neuromuscular Facilitation – Hold Relax (PNF-HR) stretching protocol is effective in increasing hamstring flexibility. **Design:** Randomized controlled trial **Setting:** Human Performance Laboratory **Patients or Other Participants:** Thirty-two subjects who met the inclusion criteria were randomly assigned to either the PNF-HR (n = 16; Age = 21.5 ± 3.5 yrs, Height = 179.0 ± 2.6 cm, Weight = 82.6 ± 4.9 kg) or control group (n = 16; Age = 21.2 ± 3.9 yrs, Height = 176.7 ± 2.8 cm, Weight = 81.8 ± 3.8 kg). Subjects were included if they had decreased hamstring ROM measured with a passive knee extension (PKE) test of less than 60 degrees, had no previous lower extremity injury within the past year, and had not participated in an intensive leg workout 48 hours prior to testing. **Interventions:** All subjects participated in one testing session. Only the subject's dominant leg was included in the study. The PNF-HR protocol consisted of 5 repetitions of 10-second hold-relax stretches finishing with a 30-second static stretch. Control subjects sat in a resting position with their hips and knees at 90º and their feet flat on the floor for 12 minutes. Hamstring flexibility was measured with an Acumar Digital Inclinometer (Lafayette Instrument, Lafayette, IN). Standardized patient positioning was created using a custom made device. The inclinometer was placed on the tibial tuberosity. PKE (degrees) was captured twice: 1) after a 5-minute warm up (Pre), and 2) immediately post treatment (Post). A visual analog scale was also used Pre- and Post-intervention to determine subject's perceived flexibility. A single-blind protocol was utilized for this study. Two repeated measures analysis of variance (ANOVA) were completed, one for each dependent variable (hamstring flexibility and perceived hamstring flexibility). **Main Outcome Measures:** Hamstring flexibility (degrees) and visual analog scale (centimeters). **Results:** A significant time by group interaction was identified for range of motion ($F_{2,30}$ = 24.0, p <.01), and perceived flexibility ($F_{2,30}$ = 9.7, p <.01). The treatment group resulted in significantly increased range of motion from Pre- to Post-test (mean difference = 6.8°). Conversely, there was no significant change from Pre- to Post-test in the control group (mean difference = 1.7°). The treatment group also perceived significantly more flexibility from Pre- to Post-test (PNF-HR mean difference = 1.4cm; control mean difference = .5cm). **Conclusions:** PNF-HR is an effective treatment for increasing hamstring flexibility in the physically active population. Not only did the treatment increase range of motion, but it also improved perceived flexibility immediately after application.

Acute Static or PNF Stretching Does Not Decrease Cramp Susceptibility in Cramp-Prone Humans

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Context: Approximately 25% (250/997) of Athletic Trainers reported stretching was the best method for preventing exercise-associated muscle cramping. Data from experimental studies demonstrating a prophylactic effect from stretching on cramp susceptibility is absent from the literature. Cramp threshold frequency (TFc), the minimum electrical stimulation frequency necessary to induce a cramp, is a quantitative method of determining cramp susceptibility. Higher TFc are associated with decreased cramp susceptibility and vice versa. **Objective:** Determine if no stretching or an acute bout of static stretching or proprioceptive neuromuscular facilitation (PNF) stretching increased TFc. **Design:** A randomized, counterbalanced, cross-over, experimental design. **Setting:** Laboratory. **Patients or Other Participants:** Fifteen healthy, cramp-prone individuals (13 males, 2 females: age = 25 ± 4 y, mass = 71.2 ± 3.1 kg, ht = 180.8 ± 8.0 cm). **Interventions:** Participants completed 1 familiarization day and 3 days of testing separated by =48 hours. On the familiarization day, we measured the dominant leg's passive hallux flexion and extension range of motion (ROM) with a goniometer. Then, flexor hallucis brevis (FHB) TFc was measured by electrically stimulating the tibial nerve (burst duration = 2 s, pulse width = 1 ms, pulse delay = 1 ms, intensity = 80 V) at a frequency of 4 Hz. If no cramping occurred, participants rested 1 minute and burst frequency was increased by 2 Hz. This process continued until the FHB cramped. On the three testing days, we measured hallux ROM. Then, we performed one of three interventions. For the static stretching condition, we stretched the FHB by holding the hallux in extension at the point of discomfort for 1 minute. For the PNF stretching condition, we performed 2 cycles, within

1 minute, of hold-relax with agonist contraction (10s static stretch with the hallux in extension; 10s FHB isometric contraction; 10s agonist contraction while pushing the hallux into extension). For the no stretching condition, subjects rested for 1 minute. This protocol was repeated twice with 1-minute rest periods separating stretches (total stretch duration = 3 min). Passive hallux ROM was reassessed and then TFc was measured. **Main Outcome Measures:** TFc (Hz) and hallux ROM (°). Descriptive statistics (mean ± SD) were calculated; repeated measures analysis of variance with Tukey-Kramer post-hoc tests were used to identify differences in TFc or ROM over time (a = .05). **Results:** PNF stretching increased hallux extension (pre-PNF = 81 ± 11°; post-PNF = 90 ± 10°; $P < .05$) but not hallux flexion (pre-PNF = 40 ± 7°; post-PNF = 40 ± 7°, $P > .05$). Similarly, static stretching increased hallux extension (pre-static = 80 ± 11°; post-static = 88 ± 9°; $P < .05$) but not hallux flexion (pre-static = 38 ± 9°; post-static = 39 ± 8°, $P > .05$). No changes in either ROM occurred with no-stretching ($P > .05$). TFc was unaffected by stretching (no stretching = 18 ± 7 Hz; PNF = 16 ± 4 Hz; static = 16 ± 5 Hz; $F_{2,28} = 1.0$, $P = .37$). **Conclusions:** Both static and PNF stretching effectively increased hallux ROM. However, neither stretching condition increased TFc. Thus, it is unlikely an acute bout of stretching provides a prophylactic effect against cramping.

The Effects of Heat on Ligament Laxity of the Ankle in Healthy Individuals

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Context: The use of heat is believed to increase range of motion. Heat has long been used in the clinical setting to increase tissue extensibility prior to exercise. In theory, an increase in flexibility reduces the risk of injury. However, there are no existing studies examining the effects of tissue temperature in ligament laxity. **Objective:** The purpose of this study was to examine the effects of heat on ligament laxity of the ankle joint. **Design:** Cross-sectional study. **Setting:** Motion Analysis Laboratory. **Patients or Other Participants:** Fifty subjects (29 females, 21 males, age = 20.0 ± 1.9 yrs; height = 172.6 ± 9.3cm, mass = 68.8 ± 13.1 kg) with no history of an ankle sprain or any other musculoskeletal injuries to the lower extremities were recruited for this study. **Interventions:** Participants were randomly divided into two groups (heat, control) and an ankle was randomly selected for testing. After signing the informed consent, a baseline measurement of anterior displacement (AD) was taken using an instrumented ankle arthrometer (Blue Bay Research Inc., Milton, FL). Participants then received the intervention of their assigned group. The heat group was administered a hydrocollator hot pack wrapped around their ankle while the control group received a rest period during the 20-minute intervention. After the intervention, another AD measurement was taken. Three trials of each measurement were taken and averaged for analysis. **Main Outcome Measures:** Data were analyzed using paired t-tests comparing the pre- to post-intervention measurements. **Results:** No significant differences were found in the pre- and post-intervention measurements in the control group (Pre: 9.30 ± 3.34 mm, Post: 9.36 ± 3.40 mm, P = 0.767). However, there was a significant increase in ligament laxity after the application of a hydrocollator hot pack in the heat group (Pre: 8.97 ± 2.71 mm, Post: 9.77 ± 2.92 mm, P = 0.029). **Conclusions:** As expected, there was no change in ligament laxity between the pre- and post-intervention measurements of the control group. However, in the heat group there was an increase in ligament laxity due to changes in the viscoelastic properties of the collagen fibers. Intuitively, an increase in temperature would increase tissue pliability. However, there is insufficient evidence supporting the effectiveness of other heating modalities such as ultrasound and short-wave diathermy on tissue extensibility. This current study, utilizing a hydrocollator hot pack heating superficial structures, provides compelling evidence to support current uses of heat by clinicians. Additional research comparing the effectiveness of superficial to deep heat and their effects on injury risk is still needed.

Immersion Ultrasound Treatment: Should Intensity Be Increased for Therapeutic Heating?

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Context: The immersion technique with therapeutic ultrasound is used when the transducer cannot be in full contact with the body part. Therapeutic modality textbooks recommend increasing the intensity up to 50% greater than the direct method parameters when using the immersion technique. However, there is limited evidence to support the amount of increased intensity needed to provide therapeutic heating with the immersion technique. **Objective:** To examine the thermal effects of an immersion ultrasound treatment at 3 MHz with a 1.0 W/cm² and 1.5 W/cm² intensities while the triceps surae was immersed in 37°C tap water. **Design:** We used a crossover repeated measures design with the independent variable as intensity (1.0 W/cm² and 1.5 W/cm²) and the dependent variable as medial triceps surae intramuscular temperature. **Setting:** University Research Laboratory **Patients or Other Participants:** A sample of 20 healthy college-aged individuals volunteered (10 males, 10 females; 23.45 ± 1.99 years). The adipose thickness over the treatment area was 0.48 ± 0.20 cm measured by diagnostic ultrasound. **Interventions:** An IT-21 intramuscular thermocouple was inserted into the medical triceps surae at a 1.5 cm depth from the treatment area. The Dynatron Solaris® 708 ultrasound machine was set to continuous, 3 MHz for 10 minutes. The intensity was set at 1.0 W/cm² for the first treatment and 1.5 W/cm² for the second treatment with at least 48 hours and no more than 10 calendar days between treatments. A template 2 times the ERA with an inside edge to keep the transducer 1 cm from the skin was used. **Main Outcome Measures:** The intramuscular temperature was recorded every

5 seconds for 10 minutes. We examined the differences in intramuscular tissue temperatures at 0, 5, and 10 minutes between the 2 intensities. **Results:** No significant differences in intramuscular temperature increases existed between the 1.0 and 1.5 W/cm² intensities ($p = 0.35$). The 1.0 W/cm² intensity increased 4.87 ± 0.40°C and the 1.5 W/cm² increased 5.19 ± 0.41°C during the 10 minute treatment. **Conclusions:** Increasing the intensity by 50% with the Dynatron Solaris® 708 did not increase the tissue temperature more than the 1.0 W/cm² intensity. However, both intensities reached vigorous heating within the 10 minute treatment. Therefore, we recommend using the lower intensity (1.0 W/cm²) due to the high BNR of the Dynatron machine. One reason we didn't see increases could be due to the lower heating capabilities of the Dynatron Solaris machine when compared to the Omnisound literature. In addition, our previous research demonstrated increases in intensity with the Dynatron Solaris® 708 didn't increase tissue temperatures. Therefore, future research should examine the effects of increased intensity during an immersion technique with a variety of ultrasound brands.

A Comparison of Blood Flow Changes in Tissues Treated With Therapeutic Ultrasound and Neuro-Muscular Electrical Stimulation

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Context: Prior research on changes in blood flow during neuro-muscular electrical stimulation (NMES) has shown both increased and decreased blood flow depending upon the electrode placement and the quality of muscular contractions elicited during the treatment. Similarly, research on blood flow changes during therapeutic ultrasound has provided mixed results. The two treatments have not been previously compared in the same study. **Objective:** To compare radial artery blood flow following therapeutic ultrasound and NMES. **Design:** Cross-over study. **Setting:** University laboratory. **Patients or Other Participants:** Thirty-six healthy volunteers (22 females, 14 males; 21.19 ± 1.65 years; 170.96 ± 9.24 cm; 70.69 ± 11.54 kg). **Interventions:** The participants were randomly assigned to therapeutic ultrasound or NMES for the first treatment session. The participants returned seven days later to receive the alternate treatment. Therapeutic ultrasound was delivered at 1MHz, continuous, 1.5 W/cm², 10 minutes. The muscle belly of the flexor-pronator mass of the non-dominant forearm was used as the treatment site. NMES was delivered at 2-Hz burst mode, 8 pulses/burst, pulse duration 180 microseconds, 15 minutes. The motor points of the flexor-pronator mass were used for surface electrode placement. Diagnostic ultrasound was used to measure radial artery blood flow volume. **Main Outcome Measures:** A group by time analysis with two groups to compare four time segments (baseline, immediate, 5 minutes post-treatment and 10 minutes post-treatment) was used to identify differences between NMES and therapeutic ultrasound. Blood flow measurements included time average mean velocity and flow volume using paired t-tests ($P < 0.05$). **Results:** There were no significant differences found between blood flow measurements when comparing therapeutic ultrasound and NMES. There were also no significant differences in blood flow when comparing measurements within therapeutic ultrasound. However, there was a significant decrease in blood flow found with NMES when comparing baseline to immediately post-treatment (flow volume in ml/min = 4.51 ± 1.79 vs. 3.81 ± 1.61; $P = 0.035$; time average mean velocity in cm/sec = 5.62 ± 2.23 vs. 4.72 ± 2.00; $P = 0.03$) and 5 minutes post-treatment (flow volume in ml/min = 4.51 ± 1.79 vs. 3.58 ± 1.68; $P = 0.012$; time average mean velocity in cm/sec = 5.62 ± 2.23 vs. 4.44 ± 2.09; $P = 0.011$), but not at 10 minutes post-treatment ($P = 0.16$). **Conclusions:** Therapeutic ultrasound has no effect on blood radial artery blood flow. NMES temporarily reduces blood flow in the radial artery immediately following treatment and at 5 minutes following treatment. NMES is useful in temporarily reducing blood flow and therefore may be beneficial in the control of edema.

The Effect of Wavelength Properties and Thermal Gradient of Various Thermal Modalities on Distal Quadriceps Intramuscular Temperature

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Context: Deep heat transfer is a goal of thermal treatments, but it involves modality wavelength, thermal gradient, and the size of modality. Clinics frequently use heat packs within infrared electromagnetic spectrum. However, when the clinical goal is to produce therapeutic levels (>1°C) of muscle heating that are maintained post-treatment, clinicians should be aware that heat transfer capability is related to more than thermal perception. **Objective:** To investigate the clinical application of heat transfer laws by comparing the perceived heat, skin surface and intramuscular heating capacity of two infrared thermal modalities and one shortwave diathermy modality. **Design:** Within repeated measure crossover design. **Setting:** Laboratory setting **Patients or Other Participants:** Fifteen volunteers including males (n = 11) and females (n = 4) (age = 23 ± 2 years, mass = 80 ± 14 kg, height = 178 ± 10 cm, thigh skin + adipose layer = 8.3 ± 4.2 mm) participated in study. All had no current injury in lower extremity. **Interventions:** One thermocouple was inserted into distal quadriceps muscle using catheter needle (~2.1 ± 0.4 cm below the skin) and a skin surface thermocouple was attached within 1 cm. The thermocouples were interfaced through an Isothermex®. Three counterbalanced 20-min conditions were compared including the Boost™ continuous shortwave diathermy (B-CSWD) unit (18in^2 pad, 13.1 MHz, 10 Watts), Thermacare™ Multi-purpose joint (TC) heatwrap (16in^2 pad), and Gel pack reusable microwavable (MHP) hot pack (15in^2 pad). **Main Outcome Measures:** Means ± SD of visual analog (VAS_p) perceived heat (cm), skin surface (T_{SKIN}) and intramuscular (T_{IM}) temperature (°C). A 3 x 2 (condition x time) GLM ANOVA with two levels of time (10 and 20 mins) investigated heat perception. Two separate 3 x 7 (condition x time) repeated measures ANOVAs with seven levels of time (5, 10, 15, 20, post5, post10, post15 mins) investigated temperature changes from baseline. Alpha was set *apriori* at 0.05. **Results:** There was a condition x time interaction for VAS_p ($p < 0.028$), T_{SKIN} ($p < 0.000$) and T_{IM} ($p < 0.004$). At 10 mins, B-CSWD (4.2 ± 1.2 cm) and MHP (3.6 ± 0.9 cm) were perceived warmer than TC (2.1 ± 1.2 cm) ($p < 0.05$), but only B-CSWD (3.9 ± 1.3 cm) ($p < 0.05$) remained warmer than TC and MHP at 20 mins. There were no differences ($p > 0.05$) in skin surface changes at 20 mins as the 95% CIs were 3.4-4.7°C (MHP), 4.1-5.9°C (TC), 3.5-5.5°C (B-CSWD). At 20 mins, B-CSWD (95% CI:1.1-2.2°C) achieved the greatest intramuscular temperature change from baseline ($p < 0.05$) compared to MHP (95% CI:0.7-1.2°C) and TC (95% CI:0.4-1.2°C). B-CSWD was able to maintain >1°C intramuscular temperature change even after 15 mins of passive recovery (95% CIs: 0.9-1.4°C)($p < 0.05$). **Conclusions:** The wavelength of thermal modality better determines the amount of deep heat transfer and intramuscular heating at ~2 cm when using thermal modalities with like-sized heat pads. Although the MHP initially felt as warm as B-CSWD, it did not produce greater deep tissue temperature increases. Therefore, one 'type' of treatment doesn't fit all clinical goals.

The Effect of Microclimates on Assessing Risk for Thermal Stress During Athletic Participation in Hawaii

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Context: Proper evaluation of the thermal environment is necessary for determining appropriate parameters for safe athletic participation with reduced risk of heat stress. The presence of microclimates has been shown to affect the ability to generalize heat related activity modification recommendations across locations of close proximity. Meteorological station data may not accurately represent on-site environmental conditions, particularly in areas where topography increases the likelihood of microclimates. **Objective:** This study evaluated the differences in heat index (HI) and wet bulb globe temperature index (WBGT) between on-site measurements at twenty-four secondary schools in Hawai`i compared to National Oceanic and Atmospheric Administration (NOAA) data collected by the closest meteorological station to each school. **Design:** Descriptive **Setting:** Secondary school outdoor athletic sites. **Patients or Other Participants:** Twenty-four secondary schools in Hawai`i on four different islands (Oahu, Maui, Island of Hawai'i, Kauai). **Interventions:** Environmental data were obtained during May through September at primary outdoor facilities on days of athletic participation between 12PM and 8PM using a Kestrel 4600 or 5400 Heat Stress Tracker (Nielsen-Kellerman, Boothwyn, PA). **Main Outcome Measures:** All HI and WBGT values were used to determine activity modification flag categories based on published recommendations. On-site HI and WBGT obtained from the Kestrel device were compared on the same days and times to HI recorded by the NOAA meteorological station and a modified WBGT calculated using the NOAA dry bulb (T_{db}) and wet bulb (T_{wb}) measurements and the following equation: $WBGT_{modified} = (T_{wb}*0.7) + (T_{db}*0.3)$. Differences between measurements were assessed using dependent t-test ($P < 0.05$). Categorization of each school as a microclimate was based on differences in HI, WBGT, and flag categories between on-site and NOAA data. Differences of flag categories were identified by comparing on-site WBGT to $WBGT_{modified}$ to determine importance of globe temperature. **Results:** Flag categories based on NOAA HI and WBGT were underestimated 65.1% (639/981) and 99.1% (924/932) of days analyzed, respectively, compared to on-site data. Twenty-one of twenty-four schools were deemed as microclimates based on significant differences in HI ($P < 0.001$) and WBGT ($P < 0.001$) and differing flag category classifications greater than 50% of days between NOAA and on-site data. $WBGT_{modified}$ produced differing flag categories compared to WBGT at least 50% of days for almost half (47%) of schools deemed as microclimates. **Conclusions:** The presence of microclimates in Hawai`i affect the ability to utilize NOAA data for determining activity modification recommendations for reducing risk of heat stress during athletic participation. On-site HI and WBGT are most appropriate for assessing risk of thermal stress and determining activity modifications. In some, but not all, cases, if obtaining on-site T_{gt} is not possible, on-site measurements of $WBGT_{modified}$ may be adequate based on T_{db} and T_{wb} to determine activity modifications.

Sex-Based Comparison of Exertional Heat Stroke Incidence in a Warm-Weather Road Race

Belval LN, Adams WM, Hosokawa Y, Huggins RA, Jardine JF, Katch RK, Stearns RL, Davis RJ, Casa DJ: Korey Stringer Institute, Department of Kinesiology, University of Connecticut, Storrs, CT; Falmouth Hospital, Falmouth, MA

Context: Previous research has hypothesized that males may be more predisposed to exertional heat stroke (EHS) than females. However, a majority of the previous studies have been conducted in male-dominant activities, such as American Football and military training. Little research exists that evaluates whether sex-based differences exist in the incidence of EHS or if EHS occurs in predominantly male activities and sports. **Objective:** To evaluate the incidence of EHS in males and females in a warm-weather road race. **Design:** Medical record review. **Setting:** 2003-2016 Falmouth Road Race (11.3 km, Falmouth, MA). **Patients or Other Participants:** 160 EHS patients from a total of 133,132 finishers across 14 years were included in the analysis. **Interventions:** Medical records of EHS patients from the race were obtained and categorized by sex and age group according to the race's results. **Main Outcome Measures:** Incidence of EHS (per 1000 finishers). An independent t-test was utilized to evaluate global differences in incidence between sex. A factorial ANOVA was used to evaluate the main effects of sex and age and the interaction between sex and age on incidence of EHS. Post-hoc Bonferroni tests of multiple comparisons were utilized to evaluate any significant relationships. **Results:** A total of 90 male and 70 female EHS patients' records were utilized for analysis. Overall incidence of EHS was 2.3 ± 1.7 EHS per 1000 finishers. No significant differences in EHS incidence occurred between sexes

(mean ± SD; male, 2.9 ± 2.4 EHS per 1000 finishers; female, 2.0 ± 1.3 EHS per 1000 finishers, $t_{26} = 1.178$, $p = 0.25$). The highest rate of EHS was observed in the female 15 - 18-year-old age group (4.4 ± 6.8 EHS per 1000 finishers). There was a main effect of age on the incidence of EHS ($F_{7,192} = 2.644$, $p = 0.012$), however we did not observe an interaction between sex and age ($F_{7,192} = 0.738$, $p = 0.640$). A significant difference in the incidence of EHS between the 15-18-year-old age group (3.7 ± 5.6 EHS per 1000 finishers) and the 75 - 100-year-old age group was observed ($p = 0.004$), however, this is due to zero occurrences of EHS in the 75 - 100-year-old age group. **Conclusions:** Based upon these results, there appears to be no difference in the incidence of EHS between sexes in this warm-weather road race. Furthermore, there were no differences in the distribution of EHS across age-groups. In light, of these results, road race medical staff should be prepared to treat EHS regardless of age-group or sex. Further research should evaluate other factors the predispose individuals to EHS independent of sex, such as fitness level anthropometric features or genetic factors.

Cold Water Immersion in the Treatment of Exertional Heat Stroke Remains the Gold Standard at the Falmouth Road Race

Katch RK, Huggins RA, Adams WM, Hosokawa Y, Belval LN, Stearns RL, Jardine JF, Davis RJ, Casa DJ: Korey Stringer Institute, Department of Kinesiology, University of Connecticut, Storrs, CT; Falmouth Hospital, Falmouth, MA

Context: Exertional heat stroke (EHS) is one of the leading causes of death in sport and physical activity. Previous research examining the Falmouth Road Race (FRR) from 1984-2011 reported 100% survival with prompt recognition via rectal temperature (T_{REC}) and treatment using cold water immersion (CWI). Since 2011, total race participation per year has increased and average number of EHS cases per 1000 finishers has decreased; however, investigation into the role these changes play on CWI's effectiveness to treat EHS has yet to be examined. **Objective:** To evaluate the effectiveness of on-site CWI in the treatment of runners suffering EHS, compare current EHS incidence rates with those previously reported, and examine the interactions between age, sex, and initial T_{REC} on cooling rate at an 11.3km, outdoor, warm-weather road race. **Design:** Descriptive study. **Setting:** FRR (Falmouth, MA). **Patients or Other Participants:** 110 runners with EHS (male n = 66, female n = 44; age 35 ± 13 yrs) from a total of 53,491 finishers from 2012-2016 were included in the analysis. **Interventions:** Medical records of runners with EHS who were treated in one of the FRR medical tents were obtained and analyzed. Runners with a $T_{REC} \geq 40°C$ and treated for EHS via CWI were included. **Main Outcome Measures:** Incidence of EHS per 1000 finishers. Cooling rate was derived from the following equation: cooling rate = (initial T_{REC} – final T_{REC}) / time in CWI (min). All descriptive variables are presented as means and standard deviations. Linear regression analysis was utilized to identify interactions between initial T_{REC}, sex, age, and cooling rates. Significance was set *a priori* at $p < 0.05$. **Results:** CWI resulted in a 100% survival rate for runners with EHS. Over the five-year collection period there were an average of 22.0 ± 11.3 EHS cases per year and an incidence rate of 2.06 ± 1.06 EHS cases per 1000 finishers. Compared to previous years (15.2 ± 13.0 cases per year; incidence rate = 2.13 ± 1.62 per 1000 finishers), this rate was a 4.5% increase in EHS cases per year and a 2.3% decrease in EHS cases per 1000 finishers. The average initial T_{REC} was 41.38 ± 0.58°C, and the average cooling rate was 0.19 ± 0.08°C·min^{-1}. No significant interactions were found between cooling rate and initial T_{REC}, age, or sex ($r = 0.055$, $R^2 = 0.003$, $p = 0.958$). **Conclusions:** CWI continues to be 100% effective in the treatment of EHS. Although an increase is observed in total cases of EHS due to an increased number of runners per year, incidence of EHS has decreased. Additionally, there was no change in cooling rate regardless of initial T_{REC}, age, or sex. Based on these results, on-site CWI is highly recommended, and remains the gold standard for the treatment of individuals suffering from EHS, despite demographic and physiological differences between runners in an outdoor, warm-weather road race.

Cooling Rates of Hyperthermic Humans Wearing American Football Uniforms When Cold-Water Immersion is Delayed

Katt GE, Di Mango TA, Miller KC: Central Michigan University, Mt. Pleasant, MI

Context: Many American football athletes have died, or have complications from, exertional heatstroke (EHS) because of lengthy treatment delays. Current recommendations include using cold-water immersion (CWI) to reduce rectal temperature (T_{rec}) within 30 minutes of collapse. If EHS treatment has been delayed, T_{rec} cooling rates should be >0.15°C·min^{-1}. Recent research suggests wearing football equipment during CWI does not affect T_{rec} cooling rates, thermal sensation, or environmental symptom questionnaire (ESQ) responses. However, it is unknown if treatment delays affect these variables in hyperthermic humans wearing football uniforms. **Objective:** We answered three questions: (1) Does wearing a football uniform and delaying CWI by 5 minutes or 30 minutes affect T_{rec} cooling rates? (2) Do T_{rec} cooling rates exceed 0.15°C·min^{-1} when treatment delays have occurred and individuals wear football uniforms during CWI? (3) How do treatment delays affect thermal sensation and ESQ responses? **Design:** Cross-over, randomized, counterbalanced, repeated measures study. **Setting:** Laboratory **Patients or Other Participants:** Ten males (age = 22 ± 2 y, mass = 78.9 ± 6.0 kg, height = 183 ± 6.9 cm). **Interventions:** On two days, participants wore a full American football uniform and exercised in the heat (38.4 ± 0.5°C, 44 ± 5% relative humidity) until T_{rec} was 39.75°C. Then, they sat in the heat for either 5 minutes or 30 minutes. Following this wait period, they underwent CWI (10.6 ± 0.1°C) while wearing a full football uniform until T_{rec} reached 37.75°C. **Main Outcome Measures:** T_{rec} was measured every 5 minutes during exercise and every 30 seconds during the wait period and CWI. CWI duration (i.e., time to 37.75°C) and T_{rec} were used to calculate cooling rates. Thermal sensation was measured pre-exercise, post-exercise, post-wait, and post-CWI. ESQ responses were measured pre-exercise, post-wait, and post-CWI. ESQ responses were summed to create a total score for each of the three measurement times. Means ± SD were calculated. Dependent t-tests were used to assess differences between conditions for exercise times, cooling rates, and post-wait $T_{rec.}$ Repeated measures analysis of variance with Tukey-Kramer post-hoc tests identified differences in thermal sensation and ESQ responses between conditions over time ($\alpha = 0.05$). **Results:** Participants exercised for similar durations (5-min delay = 45.6 ± 11.8 min; 30-min delay = 43.8 ± 11.2 min; $t_9 = 1.7$, $P = 0.12$). T_{rec} was higher following the 5-min delay (39.9 ± 0.2°C versus 39.5 ± 0.3, $t_9 = 3.8$, $P = 0.004$). T_{rec} cooling rates were unaffected by treatment delays (5-min delay = 0.20 ± 0.07°C·min^{-1}; 30-min delay = 0.19 ± 0.05°C·min^{-1}; $t_9 = 0.9$, $P = 0.4$). Thermal sensation only differed between conditions post-wait (5-min delay = 6.5 ± 0.6; 30-min delay = 5.5 ± 0.7, $P<0.05$). ESQ responses only differed between conditions post-wait (5-min delay = 27 ± 15, 30-min delay = 16 ± 12, $P < 0.05$). **Conclusions:** Longer treatment delays did not affect T_{rec} cooling rates of hyperthermic humans wearing football uniforms during CWI. Moreover, T_{rec} cooling rates exceeded the 0.15°C·min^{-1} recommendation. Participants reported feeling cooler and having lower ESQ responses following the 30-minute delay despite still being hyperthermic. In EHS situations, CWI should be initiated as soon as possible even if treatment is delayed and athletes are wearing equipment.

Master's Poster Award Finalist

Implementation of Wet Bulb Globe Temperature Policies in Secondary School Athletics

Finn AL, Adams WM, Scarneo SE, Stearns RL, Casa DJ: Korey Stringer Institute, Department of Kinesiology, University of Connecticut, Storrs, CT

Context: Wet Bulb Globe Temperature (WBGT) is an index used to measure environmental conditions and was developed to combat heat-related issues in the military. Current evidence based consensus recommends the utilization of WBGT to establish modifications for training and competition as environmental conditions become more extreme. However, the extent that these recommendations are implemented within secondary school athletics is unknown. **Objective:** To determine the extent of state high school athletics associations (SHSAAs) that require WBGT policies that meet current evidence-based best practice recommendations for sanctioned athletics. Additional consideration was given if state legislation enforces these guidelines as well as if guidelines had improved from the previous academic year (2014-2015). **Design:** Descriptive Study. **Setting:** Secondary school athletics. **Patients or Other Participants:** Not Applicable. **Data Collection and Analysis:** Nine WBGT best practice recommendations were derived from current consensus statements. An extensive review of SHSAA handbooks, constitutions, bylaws, policies and procedures, SHSAA websites, and enacted state legislation was performed for the academic year 2015-2016 to identify the inclusion of the aforementioned recommendations into mandated policies for the member schools governed by the SHSAA. Frequencies were tabulated for each recommendation. These are presented as a representative sample of the United States and District of Columbia. Percent improvement from the 2014-2015 academic year by individual recommendation was also calculated. **Results:** Of all 51 SHSAAs, two states, Georgia and Vermont, currently meet all

nine evidence-based minimum best practices for Wet Bulb Globe Temperature. Sixty-two percent of SHSAAs require their member schools to establish a heat modification policy; this is a 20% improvement from the 2014-2015 academic year. Twenty-one percent of states base their heat policy off of WBGT and 32% have a heat policy that involves at least a 4-step progression of modifications. Fifty percent of SHSAAs include equipment modification, 40% include modifications of work to rest ratios, and 42% involve modification of total practice time. Additionally, 15 (29%) SHSAAs require that modification for hydration breaks be included in their heat modification policy. Twelve percent of SHSAAs require that onsite measures of environmental conditions be used to make modification decisions. **Conclusions:** There are currently only two states that meet current evidence based minimum requirements for heat modification policies using WBGT. To optimize the health and safety of secondary school student athletes training and competing in extreme environmental conditions, appropriate policies involving the use of an onsite measure of WBGT to establish modifications of work:rest ratios, hydration breaks and equipment ensembles need to be adopted and implemented.

Doctoral Poster Award Finalist

Thermoregulatory and Circulating Stress Responses to an Intermittent Exercise-Heat Exposure Protocol to Sustain Heat Acclimation Adaptations

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Context: Heat acclimation (HA) adaptations reduce the risk of exertional heat illnesses (EHI). However, HA adaptations are temporary and must be sustained to safely perform physical activity in hot environments. **Objective:** To determine if intermittent exercise-heat exposures every fifth day mitigates HA decay and physiological stress, 25 days after initial HA (+25d). **Design:** Randomized pair-matched design. **Setting:** Research laboratory. **Patients or Other Participants:** Sixteen non-heat acclimatized recreationally active males volunteered for this study (age = 23 ± 3 y; mass = 72.9 ± 7.8 kg; VO_{2max} = 55.0 ± 5.5 $ml \cdot kg^{-1} \cdot min^{-1}$). **Interventions:** All participants completed the 10-11 day HA protocol (45-80% VO_{2max}; 90-240 min; 40°C, 40% relative humidity [RH]). A heat stress test (HST; 120 min, 45% VO_{2max}) in similar hot conditions assessed adaptation status before and after the HA protocol. Matched participants were randomly allocated into either a control group receiving exercise without heat exposures (CON; n = 7, 24°C, 21%RH) or treatment group receiving intermittent exercise-heat exposures (IHE; n = 9, 40°C, 40%RH) every fifth day for 25 days after HA. Both groups completed the +25d HST in the hot environment. Blood was drawn before and after HSTs to evaluate circulating stress markers. **Main Outcome Measures:** T-tests evaluated post-exercise HST thermoregulatory (rectal temperature [T_{re}], sweat rate, heart rate [HR]) changes before and after the HA protocol. T-tests also compared pre- to post-exercise and between group thermoregulatory and circulating stress (cortisol, epinephrine, heat shock protein 70 [HSP70]) responses to +25d HST with $\alpha = 0.05$. Mean differences (MD; CON-IHE) with confidence intervals (95% CI) and effect size (ES; Cohen's *d*) characterized the magnitude of effect. HA adaptation decay was calculated as [(+25d value - before HA value) / before HA value - after HA value)]*100. **Results:** Both groups heat acclimated, evidenced by lower post-exercise HR and T_{re}, with higher sweat rate compared to before HA ($P \leq 0.05$). At +25d, moderate-to-large between-treatment MD and ES were observed for HR (MD = 28 bpm, 95% CI [8,48], P = 0.01, ES = 1.41) and T_{re} (MD = 0.47°C, 95% CI [-0.24,1.19], P = 0.18, ES = 0.68) but not sweat rate (-0.13 $L \cdot hr^{-1}$, 95% CI [-0.47,0.21], P = 0.44, ES = 0.36). +25d post-exercise cortisol (MD = 244 $ng \cdot ml^{-1}$, 95% CI [24,465], P = 0.04, ES = 1.5) and pre- to post-exercise difference in epinephrine (MD = 0.17$ng \cdot ml^{-1}$, 95% CI [0.05,0.25], ES = 1.6) were higher in CON vs. IHE. Normalized to baseline, HSP70 concentrations increased from before to after exercise similarly in CON (MD [post-pre] = 0.43 $nmol \cdot L^{-1}$, 95% CI [0.17,0.69], $P \leq 0.032$, ES = 1.92) and IHE (MD = 0.29 $nmol \cdot L^{-1}$, 95% CI [0.02,0.60], $P \leq 0.032$, ES = 1.06) at +25d. HA adaptation decay was greater in CON vs. IHE (T_{re}: 87% vs. 2.7%; HR: 163% vs. 53%; sweat rate: 77% vs. 70%). **Conclusions:** Exercise-heat exposures every fifth day after initial HA better sustained HR and T_{re} adaptations, and reduced physiological stress compared to individuals without exercise-heat exposures. These data suggest that athletic trainers may employ intermittent exercise-heat exposures to sustain certain HA adaptations for up to one month after initial acclimation.

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