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Take this *Supplement* to St Louis and use it as a guide to the Free Communications Sessions

Dear NATA Members and Friends:

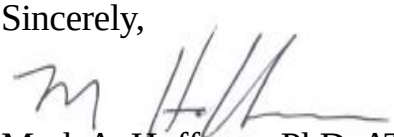
We are pleased to present the annual *Supplement* to the *Journal of Athletic Training.* This Supplement contains abstracts presented at the 2012 NATA Annual Meeting & Clinical Symposia as part of the NATA Foundation Free Communications Program.

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, Foundation-funded research, thematic posters, and clinical case reports. Abstracts of the research are printed here in the order of presentation at the NATA Annual Meeting in St. Louis 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 sessions.

We also urge you to attend the sessions featuring research funded by the Foundation. The Foundation funds research and a variety of educational programs, which include summits on issues critical to athletic training. Additionally, the Foundation funds 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 the Foundation's 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 the Foundation today at 800-TRY-NATA, extension 147. NATA and its Foundation are pleased to offer this supplement as a service to NATA members. We hope that it provides theoretical and practical information you can use to improve your effectiveness as a certified athletic trainer. Thank you for your support!

Sincerely,



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

Marjorie J. Albohm, MS, ATC
President, NATA

Dear Colleagues:

On behalf of the National Athletic Trainers' Association Research and Education Foundation and the Free Communications 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 450 submissions in the Peer Reviewed and Student Exchange Tracks, 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 study reports. 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 all of the NATA Foundation staff and especially Patsy Brown, Rachael Oats, CAE whose attention to detail and dedication makes the Free Communications Program possible. Additionally, many individuals have worked very hard to review submissions, schedule presentations, and produce this *Supplement to the Journal of Athletic Training*. Therefore, we would like to thank and recognize the efforts of the Free Communications Committee including: Joe Hart, PhD, ATC; Lisa Jutte, PhD, ATC; Tom Kaminski, EdD, ATC; Melanie McGrath, PhD, ATC; Darin Padua, PhD, ATC; Kim Peer, EdD, ATC, LAT; William Pitney, EdD, ATC; Brian Ragan, PhD, ATC; ATC, PT; Stephen Straub, PhD, ATC; Charles Thigpen, PhD, ATC, PT; Kavin Tsang, PhD, ATC and Susan Walker-Yeargin, PhD, ATC for their long hours of abstract reviews and preparation for the Free Communications programming. Lastly, we wish to thank Leslie Neistadt and the staff at the editorial office of the *Journal of Athletic Training* for making the *Supplement* possible.

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

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

Sincerely,

Jennifer E. Earl-Boehm, PhD, ATC
Vice Chair for Free Communications,
NATA Research & Education Foundation
Research Committee

Tom Dompier PhD ATC
Past Chair

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

Patrick O. McKeon, PhD, ATC
University of Kentucky

To Patrick McKeon, PhD, ATC, the importance of clinical research is matched only by the importance of the people whom you work with. Dr McKeon was first introduced to athletic training by his high school athletic trainer, Scott Ellis, MS, ATC, at New Jersey's Waldwick High School. Through Dr McKeon's work with Scott, he developed an interest in athletic training as a career and earned a bachelor's degree in athletic training from Springfield College in Massachusetts.

After 2 years as a high school athletic trainer, he decided to pursue higher education "to become a better clinician and educator." He earned his master's degree in sports health care from the Arizona School of Health Sciences, where he began to see "the value of research in substantiating decisions that we make from a clinical perspective." In other words, he became interested in "why we do what we do and how we can continue to build on the body of knowledge that is our profession." Dr McKeon went on to hold positions as an athletic trainer and clinical instructor at Canisius and Marist Colleges.

While teaching at Marist, McKeon met Jay Hertel, PhD, ATC, FNATA, FACSM, at the 2004 Eastern Athletic Trainers' Association meeting and discussed the value of pursuing a doctoral degree and conducting clinical research. At the University of Virginia, where Dr McKeon earned his doctorate, he learned important lessons from Dr Hertel about integrating elements of sensorimotor control theory and clinical practice to ask and answer clinically relevant research questions.

Today, Dr McKeon has published more than 20 research articles and is an assistant professor at the University of Kentucky, where he concentrates on graduate athletic training education and research, teaching students how to integrate evidence from research into clinical practice to enhance health care for the physically active.

Dr McKeon's research targets lower extremity injury, particularly ankle instability and related sensorimotor dysfunction, and he collaborates with Erik Wikstrom, PhD, ATC, FACSM, to explore ankle rehabilitation strategies. In addition, he works with his wife, Jennifer Medina McKeon, PhD, ATC; Tim McGuine, PhD, ATC; Phillip Gribble, PhD, ATC; and Dr Hertel, investigating clinically relevant assessments to identify ankle sprain risk factors in adolescents.

Overall, Dr McKeon wants to be remembered for his dedication to "the systemic process by which we can address clinical questions through research." He, his wife, and their mentor Dr Hertel developed what they call the "clinical scientific method" to refine the generation of evidence in athletic training research. The steps of the clinical scientific method are (1) observing and describing a clinical phenomenon, (2) developing a hypothetical model to explain the phenomenon, (3) using the model to predict outcomes, and (4) developing intervention strategies based on the hypothetical model to alter the course of the clinical phenomenon. Dr McKeon believes that this model is relevant not only for clinical research but also for clinical practice.

In addition to his wife, whom he described as his best friend, soul mate, and the greatest research partner he could ask for, Dr McKeon credits his research success to Dr Hertel. Also, he thanks his cousin, James J. Collins, PhD, for his constant inspiration and the many mentors, colleagues, classmates, friends, and students who have helped him become the scholar he is today. He especially thanks his mother, Marie, for pushing him to always go beyond the first draft, and his father, Owen, for helping him to think outside the box and blaze his own trail. Dr McKeon looks forward to guiding his son, Robert Owen, just as his mom and dad did him.

Freddie H. Fu, MD

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

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

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

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

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

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

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

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

Lindsay J. DiStefano, PhD, ATC
University of Connecticut

Similar to many athletic trainers, Lindsay J. DiStefano entered the field of athletic training to merge her interests in a career in health care and sports. Now that she has earned her PhD and ATC credentials, Dr DiStefano credits her mentors for guiding her and helping her to recognize a passion for research, teaching, and clinical practice. Although it wasn't always her dream to pursue a doctoral degree in human movement science, Dr DiStefano said, "Sometimes life just opens doors and you have to trust that everything will work out."

Dr DiStefano's willingness to walk through those open doors, as well as her hard work and dedication to research, have made her the recipient of the 2012 David H. Perrin Doctoral Dissertation Award. The majority of Dr DiStefano's research centers on sport-related musculoskeletal injury prevention with a focus on the anterior cruciate ligament, specifically in the youth population. Such injuries can be particularly traumatic in young children and teenagers because they often require surgical reconstruction and a long rehabilitation period; despite optimal care, osteoarthritis can occur and reduce the chances of remaining physically active over the lifespan. Dr DiStefano recognizes the importance of preventing such youth sport injuries from occurring in the first place. She is currently studying injury prevention programs in youth and military populations, evaluating the development of risk factors for injury in children, and investigating new methods to translate injury prevention to the community at large.

In addition to finding ways to prevent youth sport musculoskeletal injuries, Dr DiStefano also enjoys the excitement of finishing a study and figuring out the answers to some of her questions. She views research as an ongoing process because every study leads to more questions. Not only does Dr DiStefano's research answer some of her own questions, it also gives her the ability to share that information with parents and youth athletes firsthand.

Dr DiStefano has been an assistant professor at the University of Connecticut, where she teaches in the Department of Kinesiology, since 2009. As a young faculty member, her most rewarding teaching experiences so far have been watching and helping undergraduate students grow and begin their own careers.

As for her legacy, Dr DiStefano hopes to be remembered as someone known for having a passion for trying to figure out ways to keep young people safer in sports. She believes that teaching young people how to land, run, and cut with good technique should help to reduce the number of athletic injuries they sustain.

For contributing to her success, Dr DiStefano thanks mentors Sara Brown, MS, ATC; Kevin M. Guskiewicz, PhD, ATC, FNATA, FACSM; Mark Laursen, MS, ATC; Stephen W. Marshall, PhD; and Darin Padua, PhD, ATC; her parents, Nancy and James Strickland; her husband Michael DiStefano, MA, ATC and their son, Jack.

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

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

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

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

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

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

Equivalence of Alternate Forms of a Computerized Neuropsychological Test

Resch JE, Macciocchi SN, Ferrara, MS: University of Georgia, Athens, GA; The University of Texas at Arlington, Arlington, TX; Shepherd Center, Atlanta, GA

Context: Computerized neuropsychological (CNP) testing is widely utilized for sport-related concussion management. The most widely used CNP is the ImPACT. There have been several studies that have evaluated the reliability and sensitivity of the ImPACT but virtually no studies that have evaluated equivalence of ImPACT's alternate forms. Form equivalence is important to determine clinical utility of CNP testing for management of concussion. **Objective:** To determine alternate form equivalence of the ImPACT. **Design:** Repeated Measures. **Setting:** Research laboratory. **Patients or Other Participants:** Participants consisted of 108 (*N*=108), healthy, college participants aged 20.6 + 1.52 years, 171.6 + 9.71 cm tall, and mean mass of 66.9 + 11.92 kg. **Interventions:** Participants were divided into 6 equal groups and were administered alternate forms of ImPACT using clinically relevant time points (day 1, day 45, and day 50) mimicking a typical concussion recovery pattern. All participants completed a baseline evaluation using form 1 followed by a serial combination of the remaining alternate forms at day 45 and day 50. Participants were also administered Green's Word Memory Test (WMT) as a measure of effort. **Main Outcome Measures:** ImPACT calculates five composite scores: composite verbal and visual memory, visual motor speed, and reaction time. Inferential Confidence Intervals (ICI)s were calculated to compare ImPACT's alternate forms and their respective composite scores. Pearson moment correlations and independent t-tests were also utilized to further analyze alternate form equivalence. Repeated Measures ANOVA was utilized to determine changes in effort across time for Green's WMT. All analyses were performed with $\alpha = .05$. **Results:** ICIs revealed non-equivalence of composite verbal memory between form 1 and forms 2, 3, and 4. Non-equivalence was also observed between form 1 and form 3 for composite visual memory and visual motor speed. Forms 2 and 4 were non-equivalent for composite verbal memory. Forms 3 and 4 were non-equivalent for composite reaction time. Pearson *r*'s ranged from -.263 and .712 for non-equivalent forms. All participants scored greater than 85% percent on immediate and delayed recall, consistency, and paired associates of the Green's WMT suggesting good effort was provided at all time points. **Conclusions:** Alternate forms of neuropsychological tests are utilized to minimize practice effects over repeated assessments. Alternate forms of ImPACT were not equivalent for one or more composite scores. Clinicians should consider psychometric properties when interpreting results of neuropsychological testing.

Comparison of Concussion Management Programs on Return to Participation Outcomes of Concussed High School Student-Athletes During 2010-11

Kanaoka T, Oshiro RS, Furutani TM, Goeckeritz LM, Wahl TP, Kocher MH, Cleary MA, Murata NM, Uyeno RK: State of Hawaii Department of Education, Honolulu, HI; Department of Kinesiology and Rehabilitation Science, University of Hawaii at Manoa, Honolulu, HI; University of Hawaii Honolulu Community College, Honolulu, HI

Context: A multifaceted approach for the management of sport related concussion that includes a clinical examination, graded symptom check list, postural stability testing, neurocognitive testing, and Gradual Return to Play Protocol (GRPP) has been recommended by several concussion consensus statements and position papers. Health care professionals caring for concussed student-athletes across the United States may be not be following these guidelines and may be allowing student-athletes to return to participation (RTP) prematurely. **Objective**: To investigate how the duration of RTP and GRPP for concussed high school student-athletes was influenced by the type of Concussion Management Program (CMP) which incorporated two different neuropsychological testing batteries for RTP decision-making. **Design**: Retrospective cross-sectional investigation. **Setting**: Two different neurocognitive tests were utilized within a CMP in 42 public high schools in the State of Hawaii. **Patients or Other Participants**: Concussed student-athletes (*n*=426, between age 13 to 18) received baseline and post-concussion neurocognitive testing during school year (SY) 2010-11. **Interventions**: Two different neurocognitive tests used in a CMP were compared: 18 schools utilized the Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT) and 24 schools utilized Standard Assessment of Concussion (SAC). **Main Outcome Measures**: Complete data sets for days of restricted participation post-concussion (ImPACT *n*=239, SAC *n*=129), duration of the GRPP until return to unrestricted participation (ImPACT *n*=231, SAC *n*=125), and 95% confidence interval (CI). The duration of the GRPP was defined as the number of days of the rehabilitation period starting from light aerobic exercise to full-contact practice. The GRPP consisted of five steps, each separated by a minimum of 24 hr. **Results**: No significant (F_1=.277, *p*=.599) difference was found between restricted participation post-

concussion for ImPACT=17.71±11.91 (CI=16.19-19.23) days compared to SAC=18.33±7.91 (CI=16.95-19.70) days. No significant (F_1=.104, *p*=.748) difference was found for average duration of GRPP that incorporated ImPACT=8.95±5.61 (CI=8.22-9.68) days compared to SAC=9.14±4.53 (CI=8.33-9.94) days. **Conclusions**: We found that the days of restricted participation post-concussion and the duration of GRPP for concussed student-athletes was not significantly different when using the two different neurocognitive testing batteries in the CMPs. The two neurocognitive testing batteries used in this study are just one part of the multifaceted nature of the RTP decision-making as part of a comprehensive CMP. Furthermore, a CMP incorporating a neurocognitive test in addition to clinical examination, graded symptom check list, postural stability testing, and GRPP is vital to determining appropriate duration of RTP and prevent the premature release of concussed student-athletes. Injury surveillance is an important aspect of future recommendations and modification of CMPs.

The Effects of Attention Deficit Hyperactivity Disorder (ADHD) and Stimulant Medications on Performance on Concussion Assessment Tests

Littleton AC, Guskiewicz KM, Schmidt JD, Register-Mihalik JK, Gioia GA, Mihalik JP, Waicus KM: University of North Carolina, Chapel Hill, NC; Children's National Medical Center, Rockville, MD

Context: The effects of attention deficit hyperactivity disorder (ADHD) and stimulant medications on performance during concussion assessment testing are unclear. This becomes of importance when interpreting post-concussive scores relative to pre-season baseline scores in individuals with ADHD. **Objective:** 1) Examine the effects of ADHD and stimulant medications on neurocognitive and balance performance; 2) Examine differences in practice effects between an ADHD and control sample. **Design:** Prospective repeated measures design. **Setting:** Controlled clinical research setting. **Patients or Other Participants:** Thirty-four physically active participants; 17 ADHD, 17 controls (9 males, 8 females in each group); age=21.29±2.03 years. Control participants were matched to ADHD participants based on age, gender and number of previous concussions. **Interventions:** Participants were evaluated three times (7-9 days separated each session; mean=7.26±0.53 days). Participants completed a computerized neurocognitive test battery (CNS Vital Signs; CNSVS), a brief mental status examination (the Standardized Assessment of Concussion; SAC), and a postural control assessment (the Balance Error Scoring System; BESS). The ADHD participants completed sessions 1 and 2 without their stimulant medication, and session 3 on stimulant medication. Comparisons between groups and medication status (ADHD group only) were examined using separate 2 (group) x 2 (sessions 2 & 3) mixed model ANOVAs for each outcome measure. Differences in practice effects between groups were examined using separate 2 (group) x 2 (session 1 & 2) mixed model ANOVAs for each outcome measure. We employed an a priori alpha level of 0.05. Tukey post hoc analyses were employed when the omnibus tests for interaction effects were significant. **Main Outcome Measures:** CNSVS standard scores (neurocognitive index, composite memory, verbal memory, visual memory, processing speed, executive function, psychomotor speed, reaction time, complex attention and cognitive flexibility), SAC total score, and BESS total error score. **Results:** The ADHD participants performed significantly better while on medication compared to the off medication condition in overall neurocognition (measured by neurocognitive index;(103.37±9.44 vs. 97.88±8.61; $F_{1,31}$=6.03, p=0.020), processing speed (110.65± 10.27 vs.103.13±9.39; $F_{1,31}$=5.61, p=0.024), and psychomotor speed (109.75±10.34 vs. 101.19±8.04; $F_{1,31}$=8.957, p=0.005). Our healthy control participants performed significantly better on these measures compared to ADHD participants not taking stimulant medication (P<0.05 for all). The ADHD participants performed significantly better during the first session (104.56±10.15) than second session (94.38±13.95) on composite memory ($F_{1,31}$=11.40, p=0.002) and controls performed better during the first session (28.88±0.60) than second session (27.88±1.16) on SAC total score ($F_{1,32}$=7.79, p=0.009). **Conclusions:** ADHD athletes presented with improved performance on select neurocognitive domains while on their prescribed stimulant medications. Baseline and post-injury testing of ADHD athletes should occur while on medication. Clinicians should make every effort to obtain baseline neurocognitive measures for ADHD athletes because it may be especially difficult to compare post-injury scores to normative values due to differences in practice effects.

Sport Concussion Assessment Tool-2 (SCAT2) Scores Following Concussion in Adolescent Athletes With and Without a Prior Concussion History

Yakuboff MK, Mayfield RM, Chhabra A, Bay RC, Valovich McLeod TC: A.T. Still University, Mesa, AZ; The Orthopedic Clinic Association, Phoenix, AZ

Context: The SCAT2 was developed following the 3rd International Consensus Conference on Concussion as a means to improve and standardize the sideline evaluation of sport-related concussion. This tool assesses concussion-related signs and symptoms, cognition, balance, and coordination. To date, there is little known regarding the scores on this tool following a concussive injury. **Objective:** This study aimed to determine whether a prior history of concussion affects post-injury scores on

the SCAT-2. **Design:** Cross-sectional. **Setting:** Secondary school athletic training facilities. **Patients or Other Participants:** Adolescent athletes with (n=115, 107 males, 8 females, age=15.7±1.1 years, grade=10.0±1.0) and without (n=41, 33 males, 8 females, age=15.4±1.0 years, grade=9.9±1.0) a prior history of concussion, who were participating in contact interscholastic sports and sustained a concussion diagnosed by an athletic trainer. **Interventions**: A concussion history survey and SCAT2 were administered to participants at a preseason baseline. The SCAT2 was also administered on the day of injury (DOI), and days 3 (D3) and 10 (D10) post-concussion. The SCAT2 is comprised of a 22-item graded symptom scale, 2-item sign score, Glasgow Coma Scale (GCS), Maddocks questions, Standardized Assessment of Concussion (SAC), modified Balance Error Scoring System (BESS), and coordination examination. The SCAT2 total score is calculated by summing each component score, and has a maximum of 100 points. Subjects were grouped as "positive" or "negative" according to their concussion history on the preseason questionnaire. **Main Outcome Measures:** The dependent variable was SCAT2 total score. Generalized estimating equations analysis with an inverse Gaussian distribution was used following reflection transformation of the dependent variable. Sequential Bonferroni pairwise comparisons were used to determine differences ($p<.05$, two-tailed) across the 4 days for the total SCAT2 score. Lower scores on the SCAT2 indicate greater deficits. **Results:** A significant group by time interaction was found ($p<.001$). In the positive concussion group, SCAT2 total score at DOI (74.6±13.3) was significantly lower than BL (84.9±8.31), D3 (81.6±11.6), and D10 (90.1±8.6). Scores at D10 were significantly higher than BL and D3. SCAT2 total score in the negative group at DOI (72.5±14.9) was significantly lower than BL (86.1±8.4) and D10 (86.9±11.8), but not different than D3 (78.0±19.8). Scores at D3 were significantly lower than D10. There were no significant differences between positive and negative groups at any time point. **Conclusions:** Regardless of concussion history, SCAT2 scores decreased significantly at DOI, demonstrating impairments in a composite score that includes symptoms, cognition, and balance. Both groups showed improvements by D3, where scores were not different from BL. Having a prior history of concussion does not seem to result in greater deficits following a subsequent concussion on the SCAT2. Future studies should evaluate other modifying factors that could impact post-injury interpretation of the SCAT2. Funding provided by a grant from the National Operating Committee on Standards for Athletic Equipment (NOCSAE).

Does the Standardized Assessment of Concussion (SAC) Have a Ceiling Effect among Female Collegiate Athletes

Hammond N, Caswell A, Scott CB, Leyer B, Draper R, Snook EM: Department of Kinesiology, University of Massachusetts, Amherst, Amherst, MA

Context: It is important to accurately assess cognitive ability during baseline concussion screening testing. Tests with a ceiling effect (i.e. the test is too easy and everyone scores highly at baseline) are likely to underestimate the cognitive ability of some athletes during baseline testing. Underestimation of baseline ability makes the interpretation of post-concussion score changes difficult. Limited psychometric evaluation has examined whether commonly used concussion screening measures, such as the Standardized Assessment of Concussion's (SAC), have ceiling effects. **Objective:** To determine what percentage of people are underestimated with the SAC's Immediate Memory section. **Design:** Cross-sectional. **Setting:** Athletic training room offices. **Patients or Other Participants:** Thirty female athletes (19.6±1.1 years) concussion free during the previous 6 months volunteered for this study. **Interventions:** The athletes were administered a modified SAC (mSAC). The Immediate Memory section of the mSAC was modified by administering a list of 15 different words during one trial with the athlete recalling as many of the 15 words as possible. The 15 words used in the mSAC were from the three alternative word lists available for the SAC. **Main Outcome Measures:** To determine if the SAC Immediate Memory section has a ceiling effect, the mSAC was administered with the total number of words recalled being the primary outcome of interest. Any athlete capable of recalling 5 or more words from the mSAC 15-item word list would also be able to recall all 5 words from the first, second and third trial of the SAC; resulting in these athletes achieving the highest possible score of 15 for the SAC. The number and percentage of athletes scoring greater than 5 on the mSAC reflected the extent of the ceiling effect and underestimation of ability associated with the SAC. The Shapiro-Wilk test of normality was used to determine if the mSAC data were normally distributed. **Results:** The mSAC Immediate Memory data were normally distributed (Shapiro-Wilk test $P=.18$). Twenty-four athletes scored greater than 5 on the mSAC suggesting that 80% of the athletes' Immediate Memory ability is underestimated by the SAC. **Conclusion:** There is a considerable ceiling effect on the SAC's Immediate Memory section that resulted in the underestimation of baseline cognitive ability in these female athletes. The ceiling effect seen with Immediate Memory suggests that the total SAC score is not an accurate assessment of baseline cognitive ability. Because the SAC is a commonly used screening tool, replication of this study is needed in other samples of athletes to determine if a ceiling effect similar to those of this female collegiate athlete is observed in other samples.

Ceiling Effect of a Concussion Screening Measure in Male Collegiate Athletes

Smith JB, Brodeur J, Lebeda M, Chang P, Sooy J, Snook EM: Division of Athletics and Department of Kinesiology, University of Massachusetts Amherst, Amherst, MA

Context: Accurately assessing cognitive ability during baseline concussion testing is critical. If there is a ceiling effect (i.e. test is too easy and everyone scores highly at baseline) it is likely that the baseline cognitive ability of the individual's will be underestimated, making the interpretation of post-concussion changes questionable. Limited research has examined whether specific components of commonly used concussion screening measures, such as the Standardized Assessment of Concussion's (SAC), suffer from ceiling effects. **Objective:** To determine the proportion of athlete's baseline cognitive ability that is underestimated by the immediate memory section of the SAC due to ceiling effect. **Design:** Cross-sectional. **Setting:** Quiet athletic training exam room. **Patients or Other Participants:** Sixty Division I male athletes (20.6±1.3 years) with no history of concussion in the previous six months volunteered for this study. **Interventions:** The athletes were administered a modified SAC (mSAC).The Immediate Memory section of the SAC was modified from three trials of the same five words to one trial of 15 words. The 15 words used in the mSAC were from the three alternative word lists of the SAC. **Main Outcome Measures:** The total number of words recalled on the mSAC immediate memory section was the dependent variable of this study. Based on the assumption that any athlete capable of recalling 5 or more words from the mSAC 15-item word list would also be able to recall all 5 words from the first, second and third trial of the SAC. Athletes recalling 5 or more words on the mSAC should also obtain the highest possible score of 15 for the AC. The number of athletes scoring greater than 5 on the mSAC reflected the extent of the ceiling effect and the number of athletes whose baseline Immediate Memory scores were underestimated. **Results:** The mSAC Immediate Memory data were normally distributed (skewness =0.07; kurtosis =-0.23) providing evidence that the distribution of mSAC scores matched the distribution of ability levels among the athletes. A total of 38 athletes scored higher than 5 on the mSAC indicating that 80% of the athletes' Immediate Memory ability would be underestimated by the SAC. **Conclusion:** The Immediate Memory section of the SAC has a ceiling effect resulting in the underestimation of cognitive ability. The Immediate Memory score is part of the total score suggesting that the SAC provides an inaccurate assessment of baseline cognitive ability. Additional work on developing new psychometrically sound items for the immediate memory section is warranted.

Normative Baseline Values for Standard Assessment of Concussion in Healthy Male and Female High School Athletes during 2010-2011

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Context: On-site mental status is a key component of concussion evaluation and a comprehensive concussion manage-ment program (CMP). Baseline values for mental status are an important piece of data when screening for concussion or making return to participation (RTP) decisions, and may not always be available. Using age and gender-specific norms may be useful in cases where no baseline data exist. Normative values of the Standard Assessment of Concussion (SAC) for age-stratified high school athletes have not been previously reported. **Objective**: To determine differences in age and gender, and to provide normative values for SAC baseline scores of healthy high school athletes. **Design**: Retrospective cross-sectional study. **Setting:** Controlled environment free of external stimuli in 11 participating high schools. Starting in 2010, baseline concussion testing was implemented by a statewide CMP led by a contingent of athletic trainers funded by the State of Hawaii Department of Health. **Participants:** De-identified data from baseline SAC tests for 854 [age=15.2±1.2 years old (y/o), females (F) n=308, males (M) n=546] high school athletes free of injury. **Interventions:** Baseline SAC testing during 2010-2011 for all contact sport athletes was administered on an individual basis prior to their respective competitive seasons by athletic trainers who had prior knowledge utilizing the SAC. **Main Outcome Measures**: Total SAC score was compared using univariate analysis of variance on gender (M, F) and three age groups (13-14y/o *n*=314, 15-16y/o *n*=422, and 17-18y/o *n*=118). Mean, standard deviation (SD), and 95% confidence intervals were reported. **Results**: No significant (F_2= .640, *p*=.528, power=.158) differences in baseline SAC scores were found between 13-14y/o (25.89±2.53, CI= 25.61 -26.20), 15-16y/o (25.96± 2.52, CI=25.81-26.31), and 17-18y/o (25.48± 2.92, CI=25.22-26.30). Signif-icantly (F_1=9.729, *p*=.002) higher baseline SAC scores were found for females (26.31±2.40, CI=25.88-26.64) compared to males (25.62±2.65, CI= 25.31-25.79). **Conclusions**: In a large sample of high school athletes, we found no age differences and that female high athletes score better on the SAC than males. These findings suggest that a single SAC baseline may remain valid for high school athletes during their entire high school matriculation. Using the SAC on the sideline and

comparing to a normal baseline range of SAC scores may be helpful for athletic trainers when determining if scores appear reasonably valid. In cases where no baseline exists, normative data may help health care providers make return to participation decision.

Improving the Memory Items of the Standardized Assessment of Concussion through Rasch Calibration

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Context: The Standardized Assessment of Concussion (SAC) is a common concussion screening tool that is included in the Military Acute Concussion Evaluation (MACE) and the Sports Concussion Assessment Tool 2 (SCAT2). The baseline-post injury comparison recommended by the National Athletic Trainers' Association (NATA) is an individual-centered approach that emphasizes the validity and accuracy of baseline test scores. The validity of the SAC baseline memory scores has been questioned with many of the memory items not meeting acceptable psychometric thresholds. **Objective:** To evaluate the items for a new memory section on the modified SAC (mSAC) using Rasch modeling. **Design**: Cross-sectional design. **Setting:** Laboratory. **Participants:** Two-hundred participants with no history of concussion in the previous 6 months (aged 19.6 ± 2.2 years; n=93 men, n=107 women) volunteered for this study. **Intervention:** Participants completed a health history questionnaire. The mSAC test was a verbal interview taking approximately 5 minutes to complete. Ten new words were selected to make it more difficult to remember by increasing word length, examining relationships among words, and determining rhyming patterns. The administration of the memory sections changed increasing the immediate memory to 10 words repeated 1 time and the delayed memory to 10 words. The participant's responses were analyzed using the Rasch model for model-data fit. Common items were anchored based on a previous SAC calibration. **Main Outcome Measures:** Model-data fit was evaluated using infit and outfit statistics (<0.5 and >1.5). A Wright item-person map was visually inspected for the alignment of item and person estimates. Rasch modeling places items and people on the same common metric. Descriptive statistics of the participants' abilities were examined. Item difficulties were assessed. **Results:** The data fit the model with all of the new items having acceptable infit/outfit statistics (misfit). The Wright item-person map showed a good overlap between persons and items. The mean participant ability estimate was (mean ± SD) 2.55 ± 0.87 logits, where a higher score represents higher ability. The mean difficulty estimates were 2.42 ± 1.6 logits for immediate memory and 3.02 ± 0.94 logits for delayed memory. A range of ±2 SD based on participant estimates was calculated at 0.81 to 4.29 logits. All, but one item (90%) from the immediate memory section and all items (100%) in the delayed memory section fell within the range of the participant ability estimate. Item difficulties for the immediate memory section ranged from -1.39 to 3.82 logits while the delayed memory section ranged from 1.17 to 4.33 logits. The higher the logit score represents more difficult items. **Conclusions:** Rasch modeling is a powerful tool used to develop and improve measures. Despite validity issues is appears that the SAC memory section can be improved to provide valid baseline scores.

Perceptual Responses during Strength/Power Testing in Dehydrated and Rehydrated Conditions in Healthy, Resistance-Trained Men

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Context: Perceptual responses to exer-cise in a hot and humid environment may be an effective way to identify an athlete that is nearing dehydration and becoming susceptible to heat illness. **Objective:** To examine the difference in perceptual responses to dehydration followed by rehydration using a carbohydrate electrolyte (CHO) sports beverage compared to a non-caloric flavored placebo. **Design:** Double-blind randomized cross-over repeated-measures design. **Setting:** Participants were dehydrated by an overnight fast followed by active dehydration by performing a heat stress trial outdoors in a hot and humid environment ($WBGT_o$=25.5 ±1.7°C). All other testing was conducted in an air conditioned laboratory. **Participants:** Five healthy college males (age= 22.3±1.2yr, mass= 79.8±8.7kg, height=173.7±5.6 cm) who were resistance trained (anaerobic/aerobic workout 2-3 times/week) with no history of heat-induced illness. **Interventions:** Independent variables were experimental condition (CHO beverage and non-caloric flavored placebo) in two levels of hydration [dehydrated 4% body mass loss (BML) and 0% BML/euhydrated]. Investigators and participants were blind to the contents of the sports bottle containing the randomly assigned rehydration beverage. Following baseline testing, participants completed a heat stress trial until a 4.2±0.6% BML was achieved. Strength/power tests (1-repetition maximum vertical jump, back squat, and flat bench press) were conducted before and after 45 min of recovery while consuming the randomly assigned rehydration beverage. **Main Outcome Measures:** Dependent variables were perceptual responses: thirst and thermal sensations, fatigue and motivation ratings, and rating of perceived exertion (RPE) recorded before and after 4%BML/dehydrated then 0%BML/euhydrated conditions. Urine specific gravity was measured to ensure accurate hydration status. Analysis of variance with repeated measures was used to identify differences between the CHO and the placebo beverages. **Results:** Significant differences were found between tests but not conditions. Thirst sensations at pre-4% (8.2±0.3) were significantly (F_3 = 88.997, P≤.001) higher than pre-0% (1.3±0.2) and post-0% (2.3±0.4). Thermal sensations at pre-4% (5.1±0.4) were significantly (F_3=19.429, P≤.001) higher than pre-0% (2.5±0.4) and post-0% (4.2±0.5). Fatigue at pre-4% (6.3±.7) was significantly (F_3=14.093, P≤.001) higher than pre-0% (3.8±0.8) and post-0% (5.0±0.6). Motivation was not significantly different for test (F_3=1.666, P=.227, power=.329). RPE at post-4% (14.8±0.7) was significantly (F_3=7.790, P=.004) higher than pre-0% (7.4±1.2) and post-0% (13.8±0.7). **Conclusions:** We found no difference in perceptional responses when consuming CHO and non-caloric flavored placebo when performing maximal exercises in a dehydrated state. Thirst, thermal and fatigue responses were affected by dehydration which may have caused a decrease in performance compared to the euhy-drated condition. Our perceptual response questions were an accurate and reliable indication of when an athlete is nearing dehydration and may provide athletic trainers with a less invasive protocol to recognize signs and symptoms of heat illness during exercise.

Impact of Refrigeration and Freezing on Measurements of Hydration Status

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Context: Hydration status is among several variables measured to determine risk of exertional heat illness during pre-participation exams for preseason practices in summer months. To aid in the evaluation process, researchers have been seeking to identify the easiest and most valid hydration assessment methods. This research has primarily included investigations of instrumentation, but has not yet included the impact of temperature and storage of samples prior to assessment. **Objective:** To determine the impact of storage in various temperatures on the measure of urine osmolality. **Design:** Descriptive diagnostic validity study. **Setting:** Biochemical research laboratory. **Patients or Other Participants:** Seventy-five healthy participants (52 males, 23 females; mean age= 22±4years; mean self-reported height=176±23cm and mass=80±18 kg) recruited from campus provided one or more samples (total samples =83). **Interventions:** Participants completed the informed consent and a brief health history questionnaire to determine any exclusionary criteria (diabetes, kidney disease, menstruation, etc.). We provided participants with a clean specimen cup and asked them to provide a sample of 20mL of urine or more. This allowed us to separate the samples evenly into cups for the room temperature, refrigeration and frozen specimens. We analyzed the day 1, room temperature sample within 2 hours of void for osmolality using a freezing point depression osmometer. Also, within the 2 hour window, we placed the additional specimens in the refrigerator (2.4°C) and freezer (-18.0°C). On day 3, 48 hours after the void, we removed the samples from the refrigerator and

freezer. The frozen samples thawed while we analyzed the refrigerated samples. **Main Outcome Measures:** We used a one-way ANOVA to compare the room temperature sample on day 1 and day 3, the refrigerated and frozen samples. **Results:** We did not identify any significant differences ($F_{3,331}$= 0.106, p =0.96, 1-β=0.99) among the room temperature (day 1 [740±284] and day 3 [742±281]), refrigerated (747 ±283), and frozen samples (724 ±278). **Conclusion:** Our findings suggest that samples do not need to be refrigerated or frozen if assessed within 48 hours of void. For clinicians, this indicates that analysis does not need to be completed immediately and samples do not need to be stored in any specific manner other than room temperature. Clinicians should continue to evaluate urine for hydration status during pre-participation exams and preseason practices to monitor athletes for increased risk for exertional heat illness. Previous research, in combination with our findings suggest clinicians can use digital or clinical refractometers, without refrigeration or agitation within 48 hours of void to assess hydration status.

Relationship Between Self Reported Alcohol Consumption and Hydration

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Context: Research suggests that collegiate student-athletes are at an increased risk for binge drinking behaviors. Alcohol has numerous negative physiological effects, particularly in relation to hydration status. Alcohol has long been established as a diuretic with long lasting effects, which has implications for hypohydration following consumption. Hypohydration has been directly linked to decreases in performance and therefore this relationship between alcohol and hydration should be evaluated. **Objective:** To examine the relation-ship between self reported alcohol consumption and hydration. **Design:** Observational correlational design. **Setting:** Biochemical research laboratory. **Patients or Other Participants:** Five Division I athletic teams at a mid-size mid-west institution (ages of 18-26; football =15, baseball=25, softball=11, soccer =25, volleyball=15; men=40, women =51) participated in three data collection sessions. **Interventions**: During the fall athletic season, we observed the relationship between self reported alcohol consumption and hydration on three occasions: during the pre-participation physical exam (PPE), on a Sunday or Monday following an "off day" and again 3 days following. **Main Outcome Measures:** We measured hydration status using a clinical refractometer and self reported alcohol consumption using the alcohol use disorders identification test (AUDIT: range=0-40). Informed consent was acquired during an initial team meeting. Athletic Training Services performed baseline hydration status testing during PPEs, as part of regular practice for each team. Data collection on the "off day" and subsequent testing day varied by team schedule during team check-in or regularly scheduled treatment time in the athletic training facility. Athletes voided at least 20mL of urine into a specimen cup for analysis. We calculated z-scores to normalize the data and then used a Spearman's rho correlation to evaluate the relationship between dependent measures. We used a repeated-measures ANOVA to analyze hydration status over the three time sessions. We compared teams on AUDIT scores using a one-way ANOVA, and used Bonferonni corrections and post-hoc comparisons when appropriate. We established the alpha level at $p<0.05$ a-priori. **Results:** We identified no significant or strong relationships between AUDIT scores and hydration status (Spearman's rho correlation=0.003, p range=0.973). We identified significant differences in hydration status over time ($F_{2,269}$=5.226, p=0.006, η^2=0.037) with significant differences between baseline hydration status (1.017 ±0.001) and follow-up day 1 (1.021±0.001) as well as follow-up day 3 (1.020±0.001). We also identified a significant difference between sports on AUDIT score ($F_{4,86}$=4.279, p=0.003 η^2=0.166) with significant differences between athletes with the highest reported alcohol consumption from softball (9.73±1.22) and the lower reported alcohol consumption athletes in soccer (4.36±0.81) and baseball (4.36±0.81). **Conclusions:** Although we were unable to identify strong correlations between dependent measures, our results may indicate alcohol consumption has an impact on hydration status. Although other factors may have influenced hydration, we did identify significant hypo-hydration following alcohol consumption over the follow-up periods.

Free Communications, Oral Presentations: Proximal Factors Related to Knee Injuries

Wednesday, June 27, 2012, 10:45AM-12:00PM, Room 275; Moderator: Phillip Gribble, PhD, ATC

Prospective Differences in Lower Extremity Biomechanics between ACL Injured and Healthy Individuals

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Context: Few studies have prospectively compared lower extremity biomechanics of those who go on to suffer ACL injury to those who do not. However, these studies are limited by small numbers of subjects who go on to suffer ACL injury (less than 10 subjects). **Objective:** To compare knee and hip joint kinematics and kinetics between individuals who go on to suffer ACL injury and those who do not. **Design:** Cross-sectional. **Setting:** Research laboratory. **Patients or Other Participants:** 5,908 healthy, physically active participants (males=3,630;females=2,278; age=18.6±0.6 yrs, ht=173.5±9.2 cm, wt=71.9±12.9 kg) were baseline tested. 92 of the original participants later suffered a non-contact/indirect contact ACL injury after baseline testing (ACL-injured males=57, ACL-injured females=35, Healthy males=3,573, Healthy females=2243). **Interventions:** Three-dimensional knee and hip joint kinematics and kinetics were quantified using an electromagnetic motion analysis system and force plate while participants performed a jump-landing task (3-trials). **Main Outcome Measures:** Three-dimensional knee and hip joint angles and knee joint internal moments (normalized to body weight x height) were calculated at the following time points during the stance-phase of the jump-landing task: 0% (initial contact),15%, 50%, 85%, 100% (take-off). Separate mixed-model repeated measures ANOVA were performed to compare the dependent variables between groups (ACL-injured, Healthy) and sexes (males, females) across each time point of the jump-landing task (0%, 15%, 50%, 85%, 100%). Inspection of 95% confidence-intervals was performed to investigate significant interactions. **Results:** Significant group (ACL-injured, Healthy) by time (0%, 15%, 50%, 85%, 100%) interactions were observed for the following variables: knee valgus angle ($p<0.001$) [85%: Healthy=-8.7 (-9.1,-8.6), ACL-injured=-6.3 (-8.2,-4.5)], knee rotation angle ($p=0.005$) [100%: Healthy=7.7 (7.0,7.5), ACL-injured=4.9 (2.7,6.2)], hip adduction angle ($p=0.001$) [0%: Healthy=-10.2 (-9.9,-9.6), ACL-injured=-6.7 (-7.8,-5.1)], and hip rotation angle ($p<0.001$) [100%: Healthy =-10.4 (-10.2,-10.1), ACL-injured= -8.2 (-9.7,-6.1)]. No signi-ficant main effects or interactions involving group were revealed for knee and hip flexion angle or three-dimensional internal knee moments ($p>0.05$). **Conclusions:** These findings indicate that individuals who go onto suffer ACL injury demonstrate less knee valgus, knee internal rotation, hip abduction, and hip external rotation angle compared to those that do not suffer ACL injury. No interactions involve sex and group were demonstrated, thus differences in ACL-injured and Healthy groups are similar between males and females. Therefore, altered frontal and transverse plane motion control at the hip and knee appears to be important prospective risk factors for ACL injury. Future research investigating the effects of modifying frontal and transverse plane hip and knee motion and the influence on ACL injury rates is warranted.*(Funded by the NIAMS Division of the National Institutes of Health, #R01-AR050461001)*

Frontal and Transverse Plane Hip and Knee Kinetics and Kinematics During Running in Individuals with PFP

Earl-Boehm JE, Bazett-Jones D, Joshi M, Oblak P, Ferber R, Emory C, Hamstra-Wright K, Bolgla L: University of Wisconsin-Milwaukee, Milwaukee, WI

Context: Altered frontal and transverse plane kinematics of the hip and knee have been found in individuals with Patellofemoral Pain (PFP), though findings have been inconsistent. Though knee abduction moment has been related to developing PFP and to developing patellofemoral joint osteoarthritis, few studies have examined the hip and knee kinetics in PFP patients. **Objective:** The purpose was to determine if there are differences in frontal and transverse plane hip and knee joint moments and angles during running between individuals with and without PFP. **Design:** Cross-sectional. **Setting:** Research laboratory. **Participants:** 30 patients with PFP (17 females, 13 males; Age 27.5±5.6yrs; Mass 72.5±12.0kg; Height 1.75± 0.60m) and 24 control participants (13 females, 11 males; Age 28.0±7.4yrs; Mass 68.9±8.95kg; Height 1.7±0.32m) completed the study. PFP participants had pain: 3/10 for a minimum of 4 weeks, during physical activity, prolonged sitting, jumping, and/or squatting. The control group were free from lower extremity injury and had no history of PFP. All participants were active a minimum of 30 minutes at least 3 days/week. For the PFP participants the most painful knee was tested, and this was matched for the controls. **Interventions:** The independent variables were sex (Male, Female) and group (PFP, Control). Three-dimensional data were collected at 200 Hz and ground reaction force data were collected at 1000 Hz while participants ran (3.5-4.5 m/s) wearing standard

footwear. After several practice trials, 5 trials were recorded. **Main Outcome Measures:** The dependent variables were stance phase peak joint angles (hip adduction and internal rotation, knee adduction and internal rotation) and moments (hip abduction and external rotation, knee abduction and external rotation). Internal joint moments were calculated using an inverse dynamics approach, and normalized to body mass. Multivariate ANOVA, using Sidak's test for multiple comparisons, was performed to identify differences between the independent variables ($p<0.05$). **Results:** There was a significant group x sex interaction for knee abduction moment ($p=0.029$). Post-hoc comparisons indicated that males with PFP demonstrated significantly ($p=0.05$) greater knee abduction moment than control (PFPS=1.0±0.51, Control=0.70±0.22 Nm/kg). In females, there was no significant difference ($p=0.29$) in knee abduction moment between PFP (0.84±0.29Nm/kg) and Control (1.0±.50Nm/kg). Regardless of gender (group main effect, $p=0.038$), those with PFP had greater hip abduction moment than controls (PFP= -1.93± 0.29, Control=-.1.73±0.38 Nm/kg). There were no significant differences in any of the other variables measured ($p>0.05$). **Conclusions:** Individuals with PFP exhibit increased loading at the hip and knee in the frontal plane. The altered loading could result from compensatory trunk lean or pelvic drop due to weakness or pain. This study supports a growing body of literature that suggests frontal plane loading of the hip and knee is an important factor for PFP and potentially knee OA, and may be different between genders.

Comparison of Trunk and Lower Extremity Kinematics in Individuals With and Without Patellofemoral Pain

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Context: Trunk kinematics are theorized to contribute to patellofemoral pain (PFP). However, the majority of this research has been conducted in healthy individuals, and there is limited research on trunk kinematics in subjects with PFP. Understanding trunk and lower extremity kinematics in this population may improve our understanding of PFP pathomechanics and highlight new avenues for possible interventions. **Objective:** To compare trunk and lower extremity kinematics between subjects with PFP and healthy controls during a stair descent task. **Design:** Cross-sectional. **Setting:** Research laboratory. **Patients or Other Participants:** Participants included 20 females with PFP (Age: 22.2+3.1 years, Height: 164.5+9.2 cm, Mass: 63.5+13.6 kg) and 20 healthy females (Age: 21.0+2.6 years, Height: 164.5+7.1 cm, Mass: 63.8+12.7 kg). Participants with PFP met the following criteria: retropatellar knee pain with physical activity; pain on palpation of either the patellar facets or femoral condyles; and negative findings on examination of the knee ligaments, menisci, bursa, and synovial plica. **Interventions:** Each participant performed a stair descent task at a controlled pace (3 trials). A seven-camera infrared optical motion capture system was used to collect three-dimensional trunk and lower extremity kinematic data. Dependent variables included tri-planar displacement of the trunk, hip, and knee during the stance phase (initial contact to toe-off for the involved limb) during stair descent. Analysis of dependent variables was limited to the involved limb of the PFP group and matched dominant limb of the control group. **Main Outcome Measures:** Joint displacement, defined as the difference between the maximum or minimum joint angle and the angle at initial contact, was calculated during the stance phase for each dependent variable. Independent t-tests were performed to compare the dependent variables between groups. **Results:** There was a significant difference ($t38=2.082$, $p=0.044$) between groups for knee internal rotation dis-placement, with the PFP group (12.8+7.2°) displaying approx-imately 4° more knee internal rota tion displacement than the control group (8.9+4.4°). However, there were no significant between g roup differences for the other dependent variables ($p>0.05$) (PFP Group: trunk flexion=1.7+1.1°, trunk lateral flexion=1.7+1.7°, trunk rotation= -5.5+ 4.6°, hip flexion=-4.6+ 3.4°, hip adduction=10.5+4.1°, hip internal rotation=4.4+ 3.3°, knee flexion =79.7+ 5.9°, knee valgus=-2.6+5.1°; Control Group: trunk flexion=1.7+ 0.9°, trunk lateral flexion=1.6+ 0.8°, trunk rotation= -4.7+4.3°, hip flexion =-4.6+ 3.9°, hip adduction=10.9+ 4.2°, hip internal rotation=4.0+3.3°, knee flexion= 79.3+ 5.8°, knee valgus = -2.7+ 3.0°). **Conclusions:** Knee internal rotation is not typically associated with PFP. The presence of greater knee internal rotation may be a compensatory mechanism of those with PFP to decrease pain during activity by unloading the lateral facet of the patellofemoral joint. Although this study did not find differences in trunk kinematics between groups, future studies incorporating more challenging tasks to examine kinematic differences are warranted.

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Maximal Gluteal Strength Does Not Correlate with Jump-Landing Biomechanics

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Context: The Landing Error Scoring System (LESS) has been developed as a clinical tool to evaluate gross neuromuscular dysfunction during landing. Improper lower extremity biomechanics, specifically dynamic knee valgus during jump-landing may increase the risk of non-contact lower extremity injury. The proximal component of dynamic knee valgus results from internal rotation and adduction of the femur, which are controlled by gluteus maximus and gluteus medius function. Currently the relationship between gluteal strength and LESS score remains unknown. **Objective:** Investigate the relationship between bilateral gluteus maximus and gluteus medius strength and overall landing biomechanics in healthy females. **Design:** Descriptive laboratory study. **Setting:** Research laboratory. **Patients or Other Participants:** Thirty females (21.5±2.2yrs; 164.6±5.82cm, 64.84±12.0kg) with no history of lower extremity injury volunteered. **Interventions:** Bilateral gluteus maximus and gluteus medius strength were assessed using maximal voluntary isometric contractions in the midrange of motion using an isokinetic dynamometer. Strength was tested in the open-chain in prone and side lying positions for gluteus maximus and gluteus medius muscles, respectively. The order of muscle and limb tested was randomized. Following strength testing, participants performed three jump-landing trials from a 30cm box. Participants were instructed to jump off the box to a standardized distance of 50% their height, and immediately rebound to a maximal vertical jump. Each jump-landing trial was video recorded and later scored for errors. Leg dominance was determined as the leg with which each participant preferred to kick a ball. **Main Outcome Measures:** Bilateral gluteus maximus and gluteus medius strength was digitized and maximal values were exported. Two individual assessors scored the LESS, and met to resolve any discrepancies. Lower LESS scores denote better landing mechanics with fewer errors. The trial with the greatest amount of errors was included for analysis. Four separate Pearson Product Moment Corre-lations were performed to assess the relationship between the strength of the selected gluteal muscle of the dominant and non-dominant sides and LESS score. Alpha level was set *a priori* at $P \leq 0.05$. **Results:** No significant correlations were found between LESS score and strength for the dominant gluteus maximus ($r=0.003$, $P=0.99$), non-dominant gluteus maximus ($r=0.16$, $P=0.4$), dominant gluteus medius ($r=0.12$, $P=0.53$), or non-dominant gluteus medius ($r=-0.037$, $P=0.848$). **Con-clusions:** No relationships were found between gluteal muscle strength and biomechanical errors accumulated during a dynamic jump-landing task. This data provides evidence that maximal gluteal strength is not a major contributing factor to dynamic landing biomechanics. Therefore, strength may not be the most influential clinical factor in which practitioners should focus to improve poor jump-landing bio-mechanics. Future research should examine other factors besides strength, such as neuromuscular control or muscle activation and timing, which may better contribute to overall landing biomechanics.

The Effects of Hip Strength on Gluteal Muscle Activity and Lower Extremity Kinematics

Homan KJ, Norcross MF, Goerger BM, Prentice WE, Blackburn JT: University of North Carolina, Chapel Hill, NC

Context: The effects of hip muscle strength and activation on kinematic ACL loading mechanisms have been reported in isolation with equivocal results. However, the combination of these factors likely influences joint kinematics, and our understanding of ACL injury biomechanics may be improved by investigating these factors concomitantly. **Objective**: To evaluate the influence of hip strength on gluteal activation and kinematic ACL loading mechanisms. Stronger individuals were hypothesized to display similar lower extremity kinematics, but lesser gluteal activation than weaker individuals. **Design**: Cross-sectional. **Setting**: Research laboratory. **Participants**: Eighty-two healthy, physically active volunteers (41 males, 41 females; 20.9±2.4 years, 1.74±0.10 cm, 70.3±16.1 kg). **Interventions**: Hip strength and gluteus maximus (GMax) and medius (GMed) electromyo-graphic (EMG) amplitudes were measured during maximal voluntary isometric contractions (MVIC). Gluteal EMG and three-dimensional knee and hip kinematics were assessed during a double-leg jump landing task via an electromagnetic motion capture system. **Main Outcome Measures**: Peak hip extension (EXT), external rotation (ER), and abduction (ABD) forces during MVICs were multiplied by segment length to produce peak torques, and normalized to the product of subject height and weight. Knee valgus, hip internal rotation, and hip adduction angular displacements, and average GMax and GMed EMG amplitudes were identified during the loading phase of landing. Seven participants (2M, 5F) were identified as outliers and excluded from analysis. For each strength measure, the remaining participants' data were arranged into tertiles, and one-tailed independent t-

tests were used to compare landing kinematics and gluteal EMG between the highest and lowest tertiles (i.e. High vs. Low strength groups). **Results**: The High strength groups had greater hip EXT(0.013±0.017 vs. 0.080± 0.009 [x(BW*Ht)$^{-1}$], p<0.001),ER (0.057± 0.001 vs. 0.037±0.003 [x(BW*Ht)$^{-1}$], p< 0.001), and ABD (0.128±0.018 vs. 0.076±0.007 [x(BW*Ht)$^{-1}$], p<0.001) strength than the Low groups. The High strength groups exhibited similar knee valgus (EXT:-10.19±6.07º vs. -11.26±7.69º, p=0.589; ER:-9.56 ±7.04º vs. -11.74±7.60º, p=0.298; ABD :-11.22±6.96º vs. -10.13 ±7.65º, p=0.600), hip internal rotation (EXT:8.33±5.95º vs. 8.19±5.07º, p=0.929; ER:7.01±6.27º vs. 9.78± 5.53º, p=0.104), and hip adduction (ABD:4.47±3.81º vs. 3.30±2.24º, p= 0.191) displacements as the Low groups. However, GMax EMG was lesser in individuals with stronger hip extensors (55.87± 29.75 vs. 84.56± 35.14 %MVIC, p=0.003) and external rotators (33.78±22.04 vs. 45.52 ±22.94 %MVIC, p=0.057), and GMed EMG was lesser in individuals with stronger hip abductors (55.87 ±29.75 vs. 84.56± 35.14 %MVIC, p=0.071). **Conclusion**: Individuals with greater hip strength utilize lesser gluteal activation than weaker individuals while displaying similar angular displacements. Increasing gluteal strength may be important for ACL injury prevention, as weaker individuals may be susceptible to increased displace-ments during more challenging dynamic tasks due to lesser reserve neural drive (i.e. remaining %MVIC) and a potentially greater risk of fatigue. These find-ings also suggest that simultaneous assessment of muscle strength and activation are necessary when evaluating their effects on landing kinematics.

Knee EBF

Wednesday, June 27, 2012, 12:15PM-1:15PM, Room 275; Moderator: David Bazett-Jones, PhD, ATC

Regimented Sodium Replacement using Sodium Capsules Compared to Ad Lib Consumption of High Sodium Fluids on Electrolyte Balance in NFL Players during Pre-season

Bartolozzi AR, Fowkes Godek S, Morrison KE, Peduzzi C, Condon S, Burkholder R, Dorshimer GR: Pennsylvania Hospital, Philadelphia, PA; The HEAT Institute at West Chester University, West Chester PA; Philadelphia Eagles, Philadelphia, PA

Context: Previous field research indicates that sodium replacement helps maintain sodium balance, plasma volume and body weight in football players during pre-season. It is unknown whether *ad libitum* consumption of high sodium fluids maintains sodium and fluid balance as well as planned sodium replacement using fluids and sodium capsules. **Objective:** To individually replace 50% of daily sodium losses using fluids and salt capsules (Capsules) versus *ad lib* high sodium fluids only (Fluids) in NFL players during preseason and measure blood electrolytes, changes in plasma volume (%ΔPV) and body mass (%Δmass). We hypothesized that Fluids would not maintain blood sodium or increase PV compared to Capsules. **Design:** Observational cohort. **Setting:** Consecutive preseason training camps (Year1 and Year2) of one NFL team. **Patients or Other Participants:** Eleven NFL players (ht=187±5cm, mass =113.4±17kg and BSA= 2.38±0.17m^2) volunteered, 6 players participated in both years and the other 5 were physically matched. **Interventions:** We took blood samples for baseline measures when players reported to camp and prior to the morning practice on Days 3, 5 and 10. Blood electrolytes (sodium, potassium and chloride) were determined by ion-selective electrode and %ΔPV was calculated using hematocrit and hemoglobin. Baseline mass was recorded after urine samples (osmolality=681±302 mOsm·kg^{-1}) and (specific gravity=1.018±.009) ensured euhydration. %Δ mass the mornings of Days 3, 5 and 10 was calculated from baseline. Both years the players had 15 practices the first 9 days of camp. At meals players consumed sodium containing fluids and salt capsules (Year1) in amounts equal to 50% of daily sweat sodium losses, and in Year2 they were encouraged to consume as much sodium containing fluid (458 mg to g· l^{-1}) as tolerated. **Main Outcome Measures:** %ΔPV, %Δmass, blood sodium, potassium and chloride. Two-way ANOVA with repeated measures and correlated t-tests were used. **Results:** Mean WBGT during practices for days 1–9 were not different (Capsules=25±3.5ºC and Fluids= 25.5 ±3.1ºC). Sodium and %ΔPV were lower on Day3 in Fluids versus Capsules (137.8±1.4 versus 140.6± 1.5mmol·l^{-1},*P=.004*) and (-.6± 11% versus +11±10%,*P=.006*). In Fluids, chloride was lower Day3 (104± 1.9mmol·l^{-1}) compared to baseline (106.4±1.6 mmol·l^{-1}) and Day10 (106.6±2mmol·l^{-1}),*P=.05*. Potassium was higher on Day5 in Capsules (4.9± .37mmol·l^{-1}) versus baseline (4.4± .3mmol·l^{-1}), Day3 (4.4±.3mmol·l^{-1}), and Day10 (4.6±.35 mmol·l^{1})*P<.001*. PV increased over time in Capsules and on Day3 was 11% above baseline and remained there on Day5 (12.4±15%) and Day10 (9.3±10%), *P* =.04. No differences were found for %Δmass. **Conclusions:** Sodium remained constant during the first 10 days of preseason in NFL players who replaced 50% of their daily sweat sodium losses using sodium capsules. This was not the case with Fluids. Importantly, %ΔPV was higher on Day3 in Capsules (+11.4%) compared to Fluids (-.6%) which is likely clinically relevant. Results support individualized dry sodium replacement for NFL players during training camp.

Understanding Prevalence and Attitudes: Dietary and Exercise Behaviors among African American Collegiate Athletes

Lewis DW, Leaver-Dunn D, Nickelson J, Torres-McGehee T, Usdan S: The University of Alabama, Tuscaloosa, AL; University of South Carolina, Columbia, SC

Context: Historically, eating disorder research has been primarily centered on Caucasian females between the ages of 15-24 years.[1-3] The lack of inclusion of diverse minority populations from robustly designed eating disorder research has profoundly limited the generalizability for theory, treatment, and diagnosis. **Objective:** The purpose of this study was to examine eating and exercise behaviors among African-American athletes enrolled at historically black colleges and universities (HBCUs). **Design:** This study consisted of a cross-sectional analysis using non-probability convenience sampling procedures. **Setting:** The study took place during pre-participation physical examinations at two southeast regional HBCUs. **Patients or Other Participants:** The target population for this study was athletes enrolled at HBCUs (n = 128). Athletes were defined as students with full-time academic enrollment status, who have participated in NCAA or NAIA sanctioned athletic events within the study's academic calendar year. The mean age among participants was 19.7 years. The study's response rate was 35 percent. **Interventions:** Subjects completed the EAT-26, EDS-21, ORTO-15, and Pulvers' Figural Stimuli (2002) instruments; as well as additional demographic question items addressing key covariates for the purposes of control and investigation. **Main Outcome Measures:** The primary outcome measures of interest were eating disorder risk, orthorexia nervosa risk, exercise dependency risk, and body image perception. Regression analysis (Logistical and Multiple

Regression Analysis), factor analysis, ANOVA, chi-square analysis, and simple descriptive statistics served as the primary quantitative means of investigating the study's research questions. **Results:** Overall, analysis of descriptive statistics show that the percentage of participants at risk for eating disorder, orthorexia nervosa, and exercise dependency were 6 percent, 9 percent, and 30 percent respectively. MANOVA post-hoc analysis revealed that there was not a significant difference between the perceived mean Body Mass Indexes (BMIs) among subjects who classify themselves as overweight and normal weight (p = .142), with most subjects (68%) perceiving themselves as of normal weight. When accounting for actual BMI and perceived BMI, African-American participants were more likely to report that they are of normal weight when they are actually classified as overweight when compared to other races (OR = 1.873, 95%CI:1.824 – 1.944). **Conclusions:** Based upon the study's results, it is advisable for health officials to focus their attention on matching perception with reality as it relates to weight among African-American collegiate athletes. This information will aid in promoting a healthy lifestyle among participants during their post-sport lives. Continued analysis is needed to confirm the results.

Intravenous Versus Oral Sodium Replacement in Collegiate Football Players After an Exercise-induced Reduction in Body Weight by 2.5%

Fowkes Godek S, Godek JJ, Bartolozzi AR: HEAT Institute at West Chester University, West Chester, PA; DevTay Enterprises, Kennett Square, PA; Pennsylvania Hospital, Philadelphia, PA

Context: High sweat sodium losses have been documented in athletes such as football and ice hockey players, therefore, sodium replacement may be helpful for these athletes. Oral and intravenous (IV) fluid replacement have been studied but these methods have not been compared with respect to efficiency in sodium (Na^+) replacement. **Objective**: To investigate oral (Oral) versus IV Na^+ replacement as measured by Na^+ retention after exercise-induced weight loss in football players, and to evaluate thirst and ad lib fluid consumption following these methods. **Design**: Randomized cross-over study. **Setting**: Controlled University laboratory. **Patients or Other Participants**: Nine collegiate football players (age: 20.9±1.1y, height: 181.5± 3.4cm, mass: 100.3±21kg) volunteered to participate. **Interventions**: On two occasions, while HR and rectal temperature was continuously monitored, subjects exercised in an environmental chamber (35pC, 70%RH) until 2.5% body weight loss was reached. Subjects were given 1.5L of readily available, commonly used electrolyte enhanced fluids via IV (5% dextrose and 78mEq·l Na^+) or Oral (6% CHO and ~ 68mEq·l Na^+) methods during a 15 min time period immediately following exercise. At 150 min post treatment all subjects drank CHO/Electrolyte fluids ad lib. Urine Na^+ concentration (via ion-selective electrode) and urine volume (mL) were measured at 60, 120 and 180 min following treatment. Ratings of thirst (0=not thirsty to 7=very thirsty) were recorded prior to ad lib drinking at 150 min and total fluid consumed between 150 and 180 min was measured. Two-way ANOVA and correlated t-tests (with a Bonferroni correction when appropriate) were used with P<.05. **Main Outcomes Measures**: Na^+ retention(mg) at 120 min [IV or Oral Na^+ intake (mg) – urinary excretion (mg)], thirst ratings, ad lib fluid consumption (ml) and additional Na^+ intake (mg) between 150 and 180 min, and total Na^+ replacement (mg) at 180 min. **Results**: At 120 min post treatment, IV retained greater Na^+ (1665.4 ±422mg) compared to Oral (638± 451mg), P <.001. Thirst ratings were higher in IV between 30 and 60 min and between 60 and 120 min, both P<.016. However, ad lib fluid consumption between 150 and 180 min (IV =1153 ± 266ml and Oral = 886 ± 399ml), and therefore Na^+ intake (IV = 525 ±121mg and Oral = 404 ±182mg) were not different (P = .09). Total Na^+ replacement at 180 min was greater in IV (2190 ±477mg) than Oral (1042 ±517mg), P <.001. **Conclusions**: Results indicate that Na^+ replacement via IV fluids resulted in twice the sodium retention compared to oral ingestion of the same volume of electrolyte enhanced carbohydrate/electrolyte drink containing a similar amount of Na^+. A high oral sodium load may stimulate a naturetic response from the gut, therefore IV replacement may be advantageous for certain athletes when sodium retention is important.

Ferritin, Hematocrit, and Hemoglobin as Biochemical Markers of Iron Deficiency in Collegiate Runners

Rancourt CS, Eberman LE, Kahanov L, Adams H, Ingebretsen J, Landis M: Indiana State University, Terre Haute, IN; Union Hospital, Terre Haute, IN

Context: Research suggests that endurance athletes experience lower than normal hematology levels during season, which may be a result of overtraining**.** Serum ferritin has been identified as a biochemical indicator of iron deficiency and may also be insufficient in over-trained athletes. **Objective:** To observe serum ferritin, hemoglobin, and hematocrit levels of collegiate runners. **Design:** Retrospective research design. **Setting:** NCAA Division I Institution in the mid-western US. **Participants:** As part of the pre-participation physical exam, male(n=23;age=20±1; height = 69.7± 2.5in; weight= 147.4± 16.3lb; in-season mileage= 60.2± 19.6/wk; off-season mileage= 75.4± 13.0/wk) and female (n=19; age=20 ±1; height= 64.2±2.7in; weight= 126.0±14.5lb; in-season mileage= 40.1±7.9/wk; off-season mileage= 39.3±5.9/wk) cross-country and track athletes underwent blood-draw and physical history examinations. **Interventions:** Follow-

ing the examinations, we acquired access to the anonymous data for further analysis. **Main Outcome Measures:** We collected age, height, weight, gender, ferritin, hematocrit, and hemoglobin levels from all participating athletes. We used linear regression to determine the role of in- and off-season mileage on the dependent measures. **Results:** Overall, the collegiate runners demonstrated within normal limits ferritin (males=63.4±29.38ng/mL, normal range=30-400ng/mL; females =44.1±50.8ng/mL, normal range=13-150ng/mL), hematocrit (males= 41.7± 2.2%, low range<45%; females= 38.9±2.2%, low range<40%), and hemoglobin levels (males= 14.6±0.8 g/dL, normal range=13.8-18.0g/dL; females=13.7±0.7g/dL, normal range= 12.1-15.1g/dL). However when flagging athletes for low levels, we found differences in at-risk athletes based on the criteria. Ferritin flags suggested that 2 males and 1 female were lower than normal; hematocrit flags suggested that 22 males and 12 females were lower than normal; hemoglobin flags suggested that 6 males were lower than normal. We determined that among males, in-season (p=0.045) and off-season (p=0.008) mileage are significant predictors of hematocrit (r=0.662, R2=0.438, p=0.024), but not ferritin (r=0.459, R2=0.210, p=0.493). Female runners mileage was not a predictor for hematocrit (r=0.423, R2=0.179, p =0.454) and ferritin (r=0.662, R2 =0.438, p=0.024). **Conclusions:** The collected hematology levels may be an indication of over-training; however, such levels are expected of the body's response to stress and return to normal levels during periods of rest/off-season. The research suggests that observing ferritin levels alone may not be sufficient to determine iron deficiency. Hematocrit level is a more sensitive indicator of iron deficiency when triangulated with ferritin and training regime. Furthermore, in-season and off-season mileage significantly predict hematocrit among males. These findings suggest that increased mileage among males may lead to increased hematocrit levels and potentially fatigue and decreased performance.

The Secondary School Football Coach's Perspective of Sudden Death in Sport

Adams WM, McGrath BT, Mazerolle SM, Pagnotta KD, Casa DJ: University of Connecticut, Storrs, CT

Context: Prior research has examined the first aid knowledge and decision making among secondary school coaches, but little is known about their knowledge of sudden death in sport or their relationship with an athletic trainer. **Objective:** Evaluate the knowledge of the secondary school football coach regarding sudden death in sport and their relationship with their athletic trainer. **Design:** An exploratory qualitative study utilizing asynchronous online interviewing. **Setting:** Web-based management system. **Patients or Other Participants:** 38 secondary school head football coaches (37 males, 1 female) participated in this study with an average age of 47±10 years old. On average each coach had 12±9 years experience as a head football coach. **Data Collection and Analysis:** Participants responded to a series of online questions by journaling their thoughts and experiences. Questions were focused on knowledge of sudden death, prevention strategies, and professional relationships with athletic trainers. Multiple analyst triangulation and peer review were included as steps to establish data credibility. The data was analyzed borrowing from the principles of a general inductive approach. **Results:** Three dominant themes emerged from the data: *positive professional relationships, limited knowledge regarding sudden death, and self-efficacy and emergency care.* The first theme illustrated the secondary coach's positive professional relationships with athletic trainers regarding patient care and emergency procedures. Thirty-four of the 38 coaches, who participated, interacted with an athletic trainer regularly and these interactions were evaluated by the coach as positive and influential. Thirty of the 38 coaches had full-time athletic trainers on staff, 4 part-time, and the remainder were lacking medical coverage by an athletic trainer. The second theme, *limited knowledge*, reflected the secondary coach's misgiving regarding causes of sudden death as well as signs and symptoms associated with certain conditions. Many coaches were only aware of the most predominant causes of sudden death including cardiac and head injuries. They also felt dizziness and fatigue were the most important factors to diagnosis a case of heat stroke. The final theme highlights the confidence, due to basic emergency care training, of the coach regarding management of an emergency situation, despite a lack of knowledge. **Conclusions:** The secondary school football coach values and understands the role of the athletic trainer regarding patient and emergency care. The secondary coach, however, is unaware of the potential causes of sudden death in sport, symptoms associated with some conditions of sudden death, and holds a higher self-confidence in management abilities than indicated by their knowledge level. Athletic trainers, when working with the secondary coach, can have a positive influence on their implementation of strategies to prevent sudden death. Moreover, the data illustrates the importance of having an athletic trainer present to help prevent sudden death in sport, as the coach is ill-prepared.

Validity of the Heat Observation Technology System During Summer Football Conditioning

McDermott BP, Guadagno J: University of Tennessee at Chattanooga, Chattanooga, TN

Context: Body temperature assessment for the recognition of exertional hyperthermia is imperative. Despite current recommendations to assess body temperature via rectal means, there are many alternatives available. It is crucial for athletic trainers to utilize valid and reliable methods to assess body temperature. The heat observation technology (HOT) system is promoted as providing an early warning of impending heat illness. This system measures forehead skin temperature via a thermistor and, normally applies an algorithm to that reading to estimate body temperature. **Objective:** The purpose of this study was to assess the potential validity of the HOT system during outdoor summer football conditioning sessions. **Design:** Observational field study. **Setting:** Voluntary summer con-ditioning (90.0 ± 5.3°F dry bulb, 48.4 ± 5.0%RH). **Patients or Other Participants:** 20 NCAA-FCS competitive football players (20 ± 2y, 183.8 ± 7.3cm, 95.9 ± 18.3kg) voluntarily participated. **Interventions:** Participants completed normally scheduled voluntary summer conditioning workouts according to their strength and conditioning schedule. Forehead skin temperature data were collected via HOT headbands and gastrointestinal temperature (T_{GI}) via ingestible thermistors taken at least 5 hours prior to activity. Specific data points within subject were later matched for time point comparisons within 30s. **Main Outcome Measures:** T_{GI} and HOT skin temperature. **Results:** Temperature results were significantly

different between HOT (96.8 ± 2.1°F) and T_{GI} (100.7 ± 1.2°F; p<.001). There was no significant correlation between temperature readings (r = -.119; p=.070), and this relationship demonstrated that HOT readings decreased as T_{GI} increased. **Conclusions:** Our findings did not demonstrate potential validity of the HOT system to provide an accurate warning. A negative relationship between T_{GI} and skin temperatures provided by HOT suggest that no corrective algorithm could be applied either. Until independent research demonstrates the current engineering and algorithm as effective, athletic trainers should continue to utilize valid and reliable methods of temperature assessment on exercising patients.

Examination of Performance and Hydration Responses in Elite Triathletes During the Ironman World Championship Triathlon

Stearns RL, Casa DJ, DeMartini JK, Huggins RA, Munõz CX, Pagnotta KD, Volk B, Maresh CM: Korey Stringer Institute, University of Connecticut, Storrs, CT

Context: Physiological demands for extreme endurance events, such as an Ironman triathlon, are very unique. Within the limited number of athletes participating in such events, even less is known regarding the elite level athletes that compete. **Objective:** Examine the hydration responses and performance characteristics of elite level triathletes during the Ironman World Championship race. **Design:** Observational field study. **Setting:** 2011 Ironman World Championships in Kona, Hawaii (28.9°C, 71% relative humidity). **Patients or Other Participants:** 33 subjects (n=22 males, 11 females) entered in the Ironman World Championships participated (Mean± SD: age= 40± 11y; height= 174.5± 9.1cm; weight =70±11.8kg; percent body fat= 11.4 ±4.1%). **Interventions:** No intervention occurred. **Main Outcome Measures:** Data collection occurred prior to (PRE), immediately post (POST), 24 hours (24h) and 48 hours (48h) following the race. A one-way repeated measures ANOVA with Bonferroni corrections were performed to examine differences across time for perceived thirst, perceived pain, urine specific gravity (U_{sg}), urine color (U_{col}), body mass loss (BML) and percent BML (%BML). Pearson's bivariate correlations were used for comparisons with finishing time. Alpha level was set *a priori* at 0.05. **Results:** Average finish time (h:min) was 11:03±1:25h (males:10:34±1:08h, females: 12:00± 1:30h). Average sweat rate was 1.6±0.6L/h(males:1.7±0.6L/h, females :1.±0.5L/h). Significant differences occurred for POST BML (-1.7±0.9kg) vs. 24h, and 48h BML (0.9±1.4, -0.1±1.2kg, respectively; p<0.001). No significant correlation occurred between BML and finishing time (r=0.216, p=0.242). %BML at POST was 2.3±1.6% and was not correlated with finishing time (r=0.124, p=0.505). U_{sg} was significantly lower PRE (1.011±0.007) vs. POST (1.021± 0.007, p<0.001), 24h (1.024±0.008, p<0.001), and 48h (1.016±0.006, p=0.006). While 24h U_{sg} was similar to POST (p=0.15), it was significantly different from 48h U_{sg} (p=<0.001). U_{col} was significantly lower PRE (3±2), vs. POST, 24h and 48h (6±2, 6±1, 5±2 respectively, p<0.001). Thirst was significantly lower PRE (4±2) vs. POST (5±2, p=0.002), but not 24h and 48h. **Conclusions:** Participants reached thresholds for dehydration post race as demonstrated by BML and urine indices; however BML returned to baseline by 24h and U_{sg} reached euhydrated standards (U_{sg}<1.020) by 48h. BML was not correlated with a reduction in finish time. Overall these results indicate that elite triathletes were able to greatly minimize the degree of dehydration during the race (2.3% BML post race), especially considering the duration of the event and high sweat rates (estimations of total fluid losses based on sweat rates range from 15.5L for women and 18L for men). Athletes also demonstrated an ability to return quickly to pre-race body mass.

Exertional Heat Stroke EBF

Thursday, June 28, 2012, 10:30AM-11:30AM, Room 275; Moderator: David Csillan, MS, ATC

Head and Spine EBF

Thursday, June 28, 2012, 5:00PM-6:00PM, Room 275; Moderator: Ron Courson, ATC, PT

Individuals with Glenohumeral Joint Instability Maintain Stiffness and Physical Activity Levels While Displaying Diminished Health-Related Quality of Life Compared to Healthy Controls

Balam T, Huxel Bliven K, Lechtenberg J: Arizona School of Health Sciences, A.T. Still University, Mesa, AZ

Context: Glenohumeral joint (GHJ) stability relies on the integrity of its static (passive stiffness) and dynamic structures (active stiffness). Theoretically, damage to these tissues compromises passive and active stiffness, function, and health-related quality of life (HRQOL). However, understanding GHJ stiffness measures in conjunction with patient-based measures in a GHJ instability population is limited. **Objective**: Measure differences in GHJ stiffness, patient-based measures, and physical activity level between GHJ instability and healthy controls. **Design**: Cross-sectional. **Patients or Other Participants**: Thirty-five subjects of convenience were tested (GH instability: n=18; age: 26.2±6.6 yrs; height: 173.5±11.2 cm; mass: 80.5±14.7 kg, Healthy control: n=17; age: 26.8±7.3 yrs; height: 174.0±12.2 cm; mass: 80.9 ±14.9 kg). **Interventions**: Independent variables were condition [0°external rotation (ER)/ passive, 0°ER/active, 80% ER/passive, 80% ER/active] and group (GHJ instability, healthy control). Participants completed questionnaires, underwent an orthopedic screen, and stiffness tests. A customized Stiffness Testing Instrument (STI) applied a 20° ER perturbation movement (ICC = .89 to .98) while simultaneously measuring resistance torque. **Main Outcome Measures:** Using STI data, stiffness (Nm/deg) was calculated as change in displacement / change in torque. A single-item measure of perception of GHJ stability was administered after each test using a 10-cm visual analog scale ranging from 0 (no stability) to 10 (completely stable). Patient-based measures, including the Disabilities of Arm, Shoulder and Hand (DASH, 30-items, score range: 0 to 100) and Western Ontario Shoulder Instability Index (WOSI, 21-item, score range: 0 to 2100), and the International Physical Activity Questionnaire (IPAQ, 4 domains, scored using weighted linear equation) were completed. GHJ stiffness and perception of GHJ stability were analyzed using 4(condition) x 2(group) ANOVA's with repeated measures. DASH, WOSI, and IPAQ scores were analyzed using Mann-Whitney U tests. **Results:** Active stiffness (7.4±5.3 Nm/deg) was greater than passive stiffness (1.0±0.3 Nm/deg, $p<0.001$). There were no differences between 0° and 80% ER positions for passive ($p>1.00$) or active ($p=0.158$) stiffness, or between groups ($p=0.97$). Perception of GHJ stability was lower in GHJ instability than healthy control for all conditions (7.4±0.4 vs. 9.8±0.4, respectively, $p<0.05$). The GHJ instability group had higher DASH (16.2±12.7 vs. 0.6±1.3, respectively, $p<0.001$) and WOSI (665.4±383.1 vs. 41.8±62.3, respectively, $p<0.001$) scores, indicating diminished HRQOL. No differences in IPAQ scores were found (GHJ instability=492.7±479.6, healthy control=417.7±473.4, $p>0.05$). **Conclusions:** Findings of greater active than passive stiffness result from muscle contraction. The GH instability group displayed equal stiffness and physical activity levels to healthy controls, yet reported diminished perception of GHJ stability, particularly in 80% ER, and HRQOL. These contradictory results may suggest compensations in muscle activity to maintain desired physical activity levels and/or necessary GHJ stability at the expense of HRQOL. Clinicians should treat the whole-person by monitoring HRQOL in GHJ instability patients who may present with negative objective findings.

Objective and Patient-Based Measures of Glenohumeral Joint Stability Between Individuals with Glenohumeral Instability and Healthy Controls

Lechtenberg J, Huxel Bliven K, Balam T: Arizona School of Health Sciences, A.T. Still University, Mesa, AZ

Context: Glenohumeral joint (GHJ) instability limits the tissue's ability to maintain stability, which is often assessed through objective clinical measures. GHJ instability also impacts function and may ultimately diminish a patient's health-related quality of life (HRQOL). Therefore, it is important to incorporate both objective and patient-based measures into clinical assessments. **Objective:** Examine objective GHJ stability measures (laxity and stiffness) and patient- based measures (perceptions of GHJ stability and HRQOL in GHJ instability patients compared to healthy controls. **Design:** Cohort. **Patient or Other Participants:** Thirty-one subjects (GH instability: n =17; age: 26.5 ± 6.6 yrs; height: 172.7±11 cm; mass: 80.5±15.1 kg, Healthy control: n =14; age: 26.8±8.1 yrs; height: 174.6±11.7 cm; mass: 81.4±14.8 kg) of convenience were tested. **Interventions:** Participants were screened and placed into groups: GHJ instability or healthy control. GHJ stability was measured in anterior and posterior directions with the GHJ positioned in neutral and 90° external rotation (ER). **Main Outcome Measures:** GHJ laxity (mm displacement) and endpoint stiffness (N/mm) were measured using a LigMaster (SportsTech, Charlottesville, VA). A single item measure of perception of GHJ stability was administered following each test using a 10-cm visual analog scale ranging from 0 (no stability) to 10 (completely stable). Patient-based measures, including the Disabilities of Arm, Shoulder and Hand (DASH, 30-items, score range: 0 to 100) and Western Ontario Shoulder

Instability Index (WOSI, 21-item, score range: 0 to 2100) were completed by subjects. GHJ laxity and endpoint stiffness in the neutral position were analyzed with separate 2(direction) x 2(group) ANOVA's with repeated measures. GHJ laxity and endpoint stiffness in the anterior direction were analyzed using separate 2(position) x 2(group) ANOVA's with repeated measures. Patient-based measures were analyzed using separate Mann-Whitney U tests. **Results:** GHJ laxity was greater ($p=0.02$) in posterior (11.0±2.0 mm) than anterior (9.9±1.6 mm) directions with corresponding greater ($p=0.02$) endpoint stiffness in anterior (8.6±1.3 N/mm) than posterior (7.8±1.4 N/mm) directions. There were no significant differences between groups, or between anterior positions ($p>0.05$). The GHJ instability group reported less stability (6.7±2.4, $p<0.001$) in their shoulder during tests compared to healthy control (9.5±0.8). The GHJ instability group had significantly higher DASH ($p<0.001$, 15.8±13.0 vs. 2.3±5.8, respectively) and WOSI ($p<0.001$,654.2±391.9 vs. 101.5± 225.6, respectively) scores, indicating more disability and diminished HRQOL compared to healthy controls. **Conclusions:** Findings of greater posterior GHJ laxity and anterior GHJ endpoint stiffness are consistent with previous research, and may be explained anatomically. There were no group differences in objective GHJ stability measures; however, patient-based measures found the GHJ instability group perceived greater disability, and diminished GHJ stability and HRQOL than healthy controls. These findings demonstrate how GHJ instability impacts the whole-person, emphasizing the importance of using patient-based measures in clinical practice.

The Impact of Knee Injury History on Health-Related Quality of Life in College Athletes

Lam KC, Valovich McLeod TC, Snyder Valier AR, Bay RC: A.T. Still University, Mesa, AZ

Context: Health-related quality of life (HRQOL) is a multi-dimensional concept that represents an individual's overall satisfaction with his/her own sense of well-being. Patient-rated outcome measures (PROMs), such as HRQOL, capture changes that are important and meaningful to patients. While group differences in HRQOL have been reported (eg, athlete vs. non-athlete), little is known about the impact of injury history on HRQOL in college athletes. **Objective:** To determine whether HRQOL, as measured by a knee-specific (International Knee Documentation Committee form [IKDC]) and a generic (Short Form 12 [SF-12]) PROM, differs in college athletes based on the severity of a previous knee injury. **Design:** Cross-sectional. **Setting:** Athletic training facilities. **Patients or Other Participants:** Intercollegiate athletes, who were cleared for full participation, were classified into three groups based on a self-report of a previous knee injury: severe knee injury (SKI), defined as causing loss of participation for ≥ 10 days (male=17, female=31, age=19.3±1.7years, height= 174.1± 11.4 cm, mass= 71.3±13.6 kg),mild knee injury (MKI), defined as causing loss of participation for >1 but <10 days (male=20, female=19, age= 19.3±1.5 years, height= 174.0± 11.3cm, mass= 70.5±14.2 kg), and no knee injury (NKI) (male=109, female=71, age=19.1±2.5 years, height= 175.9±11.3cm, mass= 71.1± 11.9 kg). **Interventions:** Injury group was the independent variable. Participants completed the IKDC and SF-12 during one testing session. Both PROMs have published measurement properties. **Main Outcome Measures:** Dependent variables included the IKDC total score (IKDC-TS) and the 8 SF-12 subscale scores (Physical Functioning [PF], Role Physical [RP], Bodily Pain [BP], General Health [GH], Vitality [VT], Social Functioning [SOF], Role Emotional [RE], Mental Health [MH]), with higher scores indicating better HRQOL. To account for negatively skewed score distributions, generalized linear models with inverse Gaussian distributions were used following reflection transformation of dependent variables for group comparisons. Pairwise comparisons (Bonferroni) were used to determine differences across groups ($p\leq.05$). **Results:** Significant differences were reported between all groups for IKDC-TS (≤.037, SKI=76.7±2.7, MKI= 85.0±2.0, NKI=94.4±0.9). No group differences ($p>.05$) were reported for the SF-12 subscales: PF (SKI= 95.5±10.9, MKI=95.7±13.6, NKI= 98.1±8.2), RP (SKI=89.5±15.4, MKI=88.4±18.4, NKI=92.6±15.5), BP (SKI=81.0±25.5, MKI=82.9±24.6, NKI=87.7±25.3),GH (SKI= 82.6± 15.3, MKI=84.4±12.9, NKI= 85.2 ±17.1),VT (SKI= 66.5±21.2, MKI= 70.1±16.7, NKI=69.2±20.8), SOF (SKI=86.5 ±21.6, MKI=83.5 ±25.4, NKI=89.5 ±18.7), RE (SKI= 87.0± 19.4, MKI= 86.6 ±18.8, NKI=92.1 ±14.9), MH (SKI=72.3 ±20.56, MKI=77.1±18.1, NKI=78.1 ±17.7). **Conclusions:** Our results suggest that, despite returning to full participation, college athletes who previously suffered a knee injury tend to report lower knee-specific HRQOL than those with no injury history and that the severity of injury may impact knee-specific HRQOL. However, it does not appear that knee injury history impacts generic/global HRQOL. These findings suggest that specific PROMs (eg, IKDC) may better capture HRQOL deficits in athletes who return to play following injury than generic PROMs (eg, SF-12). Future studies should investigate the role of PROMs, particularly specific PROMs, as potential screening tools for patient care.

Variability in Context of Time in Athletic Training-related Patient Reported Outcomes (PROs)

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Context: Patient-reported outcomes (PRO) are essential in establishing evidence-based practice. While many PROs are available, proper selection and use is important because many are designed for specific purposes over different lengths of time. For example, when using PRO to measure the immediate impact of an injury it is important to use a measure that uses the correct context of time (e.g., last 24 hours and not over the last 4 weeks). **Objective:** The purpose of this study was to examine the variability of the context of time on common Health-related Quality of Life PROs in athletic training. **Data Sources:** PRO studies were identified from PubMed searches, and reviews of Athletic Training Journals. Search terms included "upper extremity self-report" "lower extremity self-report" and "quality of life." A total of 68 instruments were indentified from the literature. Common instruments were separated into three categories: Upper Extremity (n=26), Lower Extremity (n=27), and Quality of Life (n=15). **Study Selection:** Content experts reviewed then identified the commonly used athletic training PROs. Upper Extremity PROs included: Disability of the Arm, Shoulder, and Hand (DASH), Flex-i-level Scale of Shoulder Function, Shoulder Pain and Disability Index, Dutch Shoulder Disability Questionnaire, and the PROMIS Pediatric Upper Extremity Scale. The Lower Extremity PROs included: Knee Injury and Osteo-arthritis Score, Hip Disability and Osteoarthritis Outcome Score, Foot and Ankle Outcome Score, Foot and Ankle Ability Measure, International Knee Rating Scale, and the WOMAC Knee Scale. The Quality of Life PROs were the PedsQL, SF-12 and SF-36, and Adult Quality of Life. **Data Extraction:** The PRO context of time were identified and recorded. For example, DASH items used "Within the last 7 days…" context of time. **Data Synthesis:** The DASH, WOMAC, SF-36 were the most frequently used PROs. The most commonly used context of time, the shortest and longest context were identified. The most commonly used Upper Extremity time frame referred back to the time of injury. The shortest timeline for the Upper Extremity category was the last 24 hours and a longest time frame was within the last 6 months. Lower Extremity PRO most common and shortest time frame was the in last 7 days with the last 4 weeks the longest. The Quality of Life category had no common time frame and the shortest being daily evaluations while the longest was within the last month. **Conclusions:** With large variability in context of time across PROs, it requires that the Athletic Trainer choose the appropriate one to produce valid outcomes. The lack of a time reference on some instruments poses significant validity issues. Athletic Trainers should be aware and use the best instrument with the most appropriate time frame for their needs.

Fatigue-Specific Health-Related Quality of Life: Sex Differences in Healthy Adolescent Athletes

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Context: Fatigue is a common symptom following a sport-related concussion. The Pediatric Quality of Life Inventory Multidimensional Fatigue Scale (PedsQL MFS) is a patient-rated outcome measure that assesses fatigue-specific health-related quality of life (HRQOL). While the PedsQL MFS has been utilized during the care of chronic disease patients (eg, cancer, rheumatoid arthritis), little is known of its use in an athletic population. **Objective:** To investigate sex differences in fatigue-specific HRQOL, as assessed by the PedsQL MFS, in healthy adolescent athletes. **Design:** Cross-sectional. **Setting:** Athletic training facilities. **Patients or Other Participants:** Convenience sample of 392 female (age=15.6±1.2 years, height=164.4±8.2cm, mass=60.3±11.1 kg) and 907 male (age=15.6±1.2 years, height =175.8±8.9 cm, mass =75.0±18.4 kg) healthy adolescent athletes participating in interscholastic sports. Individuals who had a history of a prior concussion were excluded from the study because a positive concussion history has been previously associated with lower global HRQOL. **Interventions:** Gender was the independent variable. Subjects completed the PedsQL MFS during one testing session. The PedsQL MFS (reliability =.88) is an 18-item symptom-specific instrument that consists of three subscales: general fatigue (6 items: eg, "I feel too tired to do things that I like to do."), sleep fatigue (6 items: eg, "I rest a lot."), and cognitive fatigue (6 items: eg, "It is hard for me to keep my attention on things."). **Main Outcome Measures:** The general, sleep, and cognitive fatigue subscale scores were the dependent variables. Lower subscale scores indicated lower fatigue-specific HRQOL. For sex comparisons, generalized linear models with inverse Gaussian distributions were used following reflection transformation of dependent variables. This form of statistical analysis was utilized to account for the negatively skewed distribution of scores. Alpha was <.05. **Results:** Female adolescent athletes demonstrated significantly lower scores on the general (p=0.001; females =85.71±17.45, males= 89.14± 18.51), sleep (p=0.003; females =74.0±21.19, males= 77.92± 22.89), and cognitive fatigue (p=0.001; females= 83.71±28.41, males=88.73±31.00) subscales. **Conclusions:** To our knowledge, this is one of the first studies to describe the use of the PedQL MFS in an athletic population. The results of this study suggest that healthy female adolescent athletes experience lower fatigue-specific HRQOL than their male counterparts. These findings are in agreement with previous investigations in which female athletes reported lower global HRQOL than male athletes. While the differ-ences reported in this study were statistically significant, it is

unknown whether these differences are clinically meaningful. Future studies should investigate the clinical significance of these sex differences and determine the clinical usefulness of the PedsQL MFS in adolescent athletes following an injury, particularly sport-related concussions. *Funding provided by a grant from the National Operating Committee on Standards for Athletic Equipment (NOCSAE).*

The Relationship Between Baseline Concussion Symptom Clusters and Health-Related Quality of Life in Adolescent Athletes

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Context: Assessment of symptoms following sport–related concussion is central to managing athlete recovery and determining when an athlete is ready for a return-to-play progression. Symptoms are commonly grouped into a total severity score or evaluated as individual symptoms, with few studies considering the separate clusters of related symptoms and how the presence of different symptoms clusters may impact athlete health status. **Objective:** To determine the relationship between baseline self-report symptom clusters and health-related quality of life (HRQOL) in adolescent athletes. **Design:** Cross-sectional. **Setting:** High school classrooms and athletic training facilities. **Patients or Other Participants:** A convenience sample of 3739 adolescent athletes (males=74.8%, age=15.1±1.2; grade=10.1±1.1) participating in interscholastic contact sports. **Interventions:** All subjects completed the Sport-Concussion Assessment Tool-2 (SCAT2) and the Pediatric Quality of Life Inventory (PedsQL) during a single-session preseason baseline. **Main Outcome Measures:** Dependent variables include the SCAT2 physical, cognitive, sleep, emotional, and total symptom cluster (TS). Each symptom cluster represents the average symptom score for the items in each cluster, and higher scores indicate greater symptom severity. Lower PedsQL scores suggest lower HRQOL.Means and standard deviations were calculated. Relationships were evaluated with Spearman's rho (r_s) correlation coefficient, with correlations $\geq$.4 considered moderate. **Results:** The physical symptom cluster (.35±.51) was moderately correlated with the PedsQL PF (92.6±9.4; r_s=-.46), PSF (89.2 ±.10.6; r_s=-.47), and EF (89.3±.14.1; r_s=-.45) subscale scores and the TS (90.4±.9.2; r_s=-.51). The cognitive symptom cluster (.47±.79) was moderately correlated with the PedsQL SCF (84.7±.14.7; r_s= -.52) and PSF (r_s=-.54) subscales and the TS (r_s= -.54). The sleep symptom cluster (.49±.72) was moderately correlated with the PedsQL EF (r_s= -.54), PSF (r_s= -.51), PF (r_s=-.52), and SCF (r_s=-.40) subscales and the TS (r_s=-.56). The emotional symptom cluster (.38±.70) was moderately correlated with the PedsQL EF (r_s= -.55), PSF (r_s=-.51), PF (r_s=-.42) subscales and the TS (r_s=-.53). The total symptom score (.39±.53) was most highly correlated with the PedsQL TS (r_s=-.65), followed by PSF (-.60), EF (-.57), PF (-.54), and SCF (-.50). SOF (93.6±10.6) was not moderately correlated (r_s<.4) with any symptom cluster. **Conclusions:** These data suggest that, generally, baseline self-report symptom reports are related to HRQOL, with more self-reported symptoms associated with lower HRQOL. Of particular interest are the moderate correlations between related symptom clusters and HRQOL subscales, such as emotional symptoms and emotional HRQOL, and physical symptoms and physical HRQOL, which suggests that the HRQOL instrument captures valid and meaningful patient-oriented information. Moreover, these data suggest that even at baseline, adolescent athletes have meaningful symptomatology that impacts their HRQOL in a number of health domains. Impact of symptomatology on HRQOL following concussion warrants evaluation when considering athlete clearance for return-to-play. *Funded by a grant from the National Operating Committee on Standards for Athletic Equipment (NOCSAE)*

School Absence, Academic Accommodation and Health-Related Quality of Life in Adolescents with Sport-related Concussion

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Context: Recognition of the impact of adolescent sport-related concussion (SRC) on academic performance is increasing. However, little is known about the academic needs of adolescent patients, or the impact of SRC on education or patient health-related quality of life (HRQOL). **Objective**: To determine the frequency of school absence and academic accommodation, accommodation type, and relationship to both clinical and patient-centered outcomes measures, including HRQOL, following SRC. **Design**: Cross-sectional. **Setting**: Secondary school athletic training facilities. **Patients or Other Participants**: Interscholastic athletes participating in contact sports who suffered a concussion diagnosed by an athletic trainer (n=149; males=130, females=19, age=15.7 ±1.1,grade=10.0±1.0). **Interventions**: The Sport-Concussion Assessment Tool-2 (SCAT2) was administered on the date of injury (DOI), days 3(D3), and 10(D10). Only the SCAT2 symptom scales were administered 30 days (D30) post-injury. The following measures were also administered D3, D10, and D30: general survey; Pediatric Quality of Life Inventory (PedsQL) including 5 subscales [physical (PF), psychosocial (PSF), emotional (EF), social (SOF), and school functioning (SFS)]; Multidimensional Fatigue Scale (MFS) including 3 subscales [general (GF), sleep (SLF), and cognitive (CF) fatigue]; and Headache Impact Test (HIT-6). The general survey captured school absences, occurrence of academic accommodations and type (9-item list of accommodation types

based on expert opinion). All other measures have established reliability and validity. **Main Outcome Measures**: Dependent variables included occurrence of: 1) school absence and 2) academic accommodation; and 3) type of accommodation received. Data were analyzed with descriptive and frequency analyses and Mann-Whitney U tests. **Results**: School absence and accommodations data were collected for 144 patients: 27.8% (n=40) missed school, and 16% (n=23) received academic accommodations because of concussion. Accommodation types received: shorter day [n=9(39%)]; other [n=7(30.4%)]; rest breaks [n=5(21.8%)]; note taker [n=5 (21.8%)]; special permissions [n=5(21.8%)]; less homework [n=3(13%)]; individualized learning plan [n=2(8.7%)]; shorter classes [n=1(4.3%)]. For those requiring accommodations, Mann-Whitney U tests revealed significant differences (P<.05) in: number of school days missed; D3 PF, PSF, and SFS, and PedsQL total score; D30 HIT6 total score. For those with school absences, Mann-Whitney U tests revealed significant difference in: DOI balance, feelings of slowness, feeling fatigue, confusion, drowsiness, sleep problems, irritability, total symptom severity and endorsements (all p<.05), and DOI SCAT2 total score (p<.01); D3 PF (p<.05), PFS (p<.01), SFS (p=.001), PedsQL total score (p<.05), and SLF (p<.05); D10 HIT6 total (p<.05) **Conclusions**: Within 30 days of SRC, 28% of patients missed school, and 16% required academic accommodations. A shorter school day is the most frequently employed accommodation. Missing school or receiving accommodation is associated with significant differences in a variety of clinically oriented and HRQOL measures across the 30-day period. Results suggest that certain measures may be predictive of later academic disruptions. Future prospective studies in this area are required.

Correlation Between Self-Report Ankle Function and Dynamic Postural Stability in Recreationally Active Individuals

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Context: The Cumberland Ankle Instability Tool (CAIT) has been used to assess self-reported ankle function in those with chronic ankle instability (CAI). The Dynamic Postural Stability Indices (DPSI) have been used the assess ability to transition to a static balance state during landing. It is currently unclear if there is a relationship between CAIT and DPSI score. **Objective:** To determine the relationship between CAIT score and DPSI components. **Design:** Correlational. **Setting:** Biomechanics Laboratory. **Patients or Other Participants:** Twenty-three participants (9 Male, 14 female; age=22.4 ± 3.7yrs; height=172.1 ± 8.8cm; mass=77.4 ± 14.4kg) participated in this study. Participants reported variable ankle injury history, ranging from no history of sprain to a history of moderate-severe sprain with or without residual complaints of instability. **Interventions:** In a single testing session participants completed the CAIT, then performed the dynamic balance assessment (the DPSI task). Participants performed 50% maximum vertical jumps, landing on a force-plate (1200Hz) 70cm in front of them on a single leg, stabilizing as quickly as possible. Five successful trials were performed on each leg and averaged. Order of limb testing was randomized. Pearson bivariate correlations were calculated between the CAIT and each DPSI components (anterior-posterior AP, medial–lateral ML, vertical V, and composite DPSI). A Bonferroni correction was applied, with significance set a priori at $p<0.0125$. **Main Outcome Measures:** CAIT scores for each limb and AP, ML, V and DPSI scores for each limb were correlated. Higher CAIT scores indicate better self-reported function, and lower DPSI scores indicate better dynamic stability. **Results:** Mean and standard deviation for the CAIT was 25.1 ± 6.5 while each DPSI components' mean and standard deviations were APSI 0.09 ± 0.02; MLSI 0.29 ± 0.20; VSI 0.33 ± 0.06; DPSI 0.48 ± 0.13. There was a significant correlation between MLSI and CAIT (r=-0.44, p=0.003) and DPSI and CAIT (r = -0.42, p=0.004). Neither APSI (r=0.32, p= 0.032) nor VSI (r=0.11, p=0.487) were significantly correlated with CAIT. **Conclusions:** These results suggest that participants with lower perceived functional stability in their ankle (lower CAIT scores) also tended to exhibit greater dynamic postural instability, as evidenced by higher ML and DPSI scores. The strength of the relationship was only moderate, but was statistically significant. Interestingly, the relationship between self-report function and AP and V stability indices were not significant. As excessive inversion is a primary mechanism causing a lateral ankle sprain, the MLSI component of the DPSI may play a more important role in ability to stabilize from a jump landing.

Ankle Questionnaires Poorly Correlate with Dynamic Postural Stability in Subjects with Functional Ankle Instability

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Context: Subjects with functional ankle instability (FAI) exhibit impaired dynamic postural stability (DPS). Questionnaires have been developed to determine the presence of FAI; however, the relationship between questionnaires and specific functional deficits FAI subjects possess, DPS, is largely unknown. **Objective**: To

determine if DPS deficits exist in FAI subjects and to identify the relationship between questionnaires and DPS in recreationally active male subjects with FAI. **Design**: Cross-sectional study. **Setting**: Research laboratory. **Participants**: Data were collected on 12 subjects with FAI (age=21.2±1.4 years, height= 182.2± 5.7 cm, mass=84.9±7.8 kg) and 12 control subjects (age=22.2± 1.1 years, height=178.6±6.5cm, mass =77.9±8.7 kg). Inclusion criteria for the FAI group were a history of at least 2 lateral ankle sprains and episodes of the ankle feeling unstable in the previous year. Inclusion criteria for controls were no previous ankle sprains or feelings of instability. **Interventions**: The questionnaires consisted of the Foot and Ankle Disability Index-Sport (FADI-S), Ankle Instability Instrument (AII), Ankle Joint Functional Assessment Tool (AJFAT), and the Cumberland Ankle Instability Tool (CAIT). Singe-leg jump landings in the anterior and lateral directions were utilized to assess DPS. Subjects were positioned 40% and 33% of their height from the edge of a force plate and a 30cm and 15cm hurdle placed at the midpoint, respectively. Subjects were instructed to land in the middle of the force plate, stabilize as quickly as possible, and remain motionless for 5 seconds. Three trials were collected in each direction. Independent t-tests were used to assess group differences in DPS and questionnaire scores. Pearson's correlation coefficients were calculated to determine the relationship between questionnaires and DPS. Statistical significance was set at $p<0.05$ *a priori.* **Main Outcome Measures**: Each questionnaire was scored according to its instructions. Stability indices in the three principal directions (anterior-posterior [APSI], medial-lateral [MLSI], and vertical [VSI]) and the Dynamic Postural Stability Index (DPSI) were calculated to quantify DPS. **Results**: Significant differences existed between groups for the FADI-S (FAI=87.0±14.1, Control=94.2±3.2,p=0.015),AII (FAI=4.3±1.6,Control=0.0± 0.0, p<0.001), AJFAT(FAI =17.7±4.2, Control=26.2±0.4, p<0.001), and CAIT (FAI=23.0 ±3.8,Control =29.6±0.8, p<0.001). Significant differences were noted for the VSI(FAI=0.37±0.03, Control= 0.33± 0.04, p=0.003) and DPSI (FAI= 0.40± 0.03, Control=0.35±0.04, p=0.004) during the anterior jump. Similar results were seen for the VSI (FAI=0.35±0.03, Control=0.31±0.06, p=0.029) and DPSI (FAI=0.37±0.03, Control= 0.33±0.05, p=0.025) during the lateral jump. Significant correlations were observed between the MLSI and the AJFAT (r=0.61, p=0.035) and CAIT (r=0.73, p=0.006) during the lateral jump. **Conclusions**: Subjects with FAI demonstrate impaired DPS compared to controls. Moderate to good correlations were observed between the AJFAT and CAIT and the MLSI during the lateral jump. The questionnaires were able to detect differences between groups but overall poorly correlated with DPS suggesting the questionnaires may be inadequate at detecting specific functional deficits in FAI subjects.

Ankle Laxity is Correlated to Self-Report Function and Dynamic Postural Stability Index

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Context: Chronic ankle instability (CAI) is a common outcome following lateral ankle sprain. The role of pathologic ligamentous laxity in CAI is unclear, and may mitigate self-report function and ability to stabilize during jump landing. **Objective**: To determine if there is a relationship between ligamentous laxity and self-report ankle function questionnaires and dynamic postural stability index (DPSI) composite score in recreational athletes. **Design:** Correlational. **Setting:** Biomechanics Laboratory. **Patients or Other Partici-pants:** Twenty-three volunteer recreational athletes (14 males, 9 females, age 22.3±3.7 years, height 172.1±8.8cm, mass 77.4± 14.4kg). Participants reported at least 30 minutes of exercise, 3 times per week. They reported variable ankle injury histories including no history of ankle sprain, or history of moderate-severe ankle sprain with or without residual instability. **Interventions:** Participants answered demographic questions regarding activity level and ankle injury history. They completed the Cumberland Ankle Instability Tool (CAIT) for the right and left limbs, and the Foot and Ankle Disability Index and Sport Subscale (FADI, FADI-S) for the involved limb or matched limb. Participants stood 70cm from an in-ground force plate and performed an anterior vertical jump to 50% of their measured maximum. Participants landed on a single leg and balanced for 3 seconds. Five successful trials were collected on each limb in a randomized order. The force plate (1200Hz) collected ground reaction forces. Lateral ankle ligament laxity to inversion was measured using an instrumented arthrometer on both ankles. Bivariate Pearson correlations were conducted with a Bonferonni correction of α= 0.0125. **Main Outcome Measures:** Scores were calculated for CAIT, FADI, and FADI-S question-naires. DPSI composite score was calculated and averaged for each leg. Ankle inversion displacement was recorded from the instrumented arthrometer and averaged over 2 trials for each leg. The relationships between displacement value and DPSI composite score, and displacement value and questionnaire score were assessed via bivariate Pearson correlation coeffi-cients. **Results:** Means and standard deviations for the questionnaire scores were CAIT 25.0±6.4; FADI 96.3±9.1; FADI-S 91.9±11.3 while displacement was 34.0±7.0mm and DPSI 0.48±0.13. DPSI is a unitless value. Displacement was significantly negatively correlated with the CAIT, FADI, and FADI-S (r= -0.40 p=0.008; r=-0.43, p=0.003; r= -0.41, p=0.006, respectively). Displacement was significantly positively correlated with DPSI (r=0.38, p=0.010). **Conclusions:** As ankle laxity increased, self-reported ankle function decreased. Additionally, as

laxity increased, so did DPSI score, indicating worse performance on stabilizing as evidenced by larger values. While the correlations were only moderate, it appears increased laxity may contribute to difficulty stabilizing during single leg landing and reported difficulties in sporting and daily living activities.

Development of the Identification of Functional Ankle Instability (IdFAI)

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Context: Self-reported questionnaires are a common method used in identifying individuals with ankle instability. Recently, a study illustrated the singular use of any of the most frequently utilized questionnaires failed to significantly predict ankle stability status. **Objective**: Present information related to the development, reliability and validity of a new questionnaire, the Identification of Functional Ankle Instability(IdFAI). **Design:** Cross Sectional Study **Setting:** Classroom setting **Patients or Other Participants:** A total of 278 participants were recruited from the university population. Individuals with a history of a lower limb fracture were excluded from the study. All 278 individuals (125 males, 153 females, 19.75±1.43 years) participated in the development portion of this study and a subset of 110 individuals (54 males, 56 females, 19.80±1.40 years) participated in the reliability and validity portion. **Interventions:** All 278 participants completed the initial IdFAI on one occasion. The initial IdFAI was created from the Ankle Instability Instrument and Cumberland Ankle Instability Tool and consisted of 28 questions. These questions focused on the history of ankle sprains, presence and severity of ankle instability, and functional performance. Item reduction was completed using an exploratory factor analysis with principal axis factoring as the extraction method with varimax rotation. Additionally, a discriminant function analysis was conducted to identify a discrimination score. A subset of the participants (n=110) completed the IdFAI on two occasions (two weeks apart) and the Lower Extremity Functional Screen(LEFS) on one occasion. The LEFS is a widely-used questionnaire that measures overall lower extremity function. IdFAI test-retest reliability was evaluated by intraclass correlation coefficient ($ICC_{2,1}$).Concurrent validity was evaluated by comparing the IdFAI with the LEFS using a Spearman ρ. **Main Outcome Measures:** The dependent variables were the total scores on the IdFAI and the LEFS. **Results:** The factor analysis revealed 3 factors. Factor 1(4 questions) explained 53.7% of the variance, factor 2(4 questions) explained an additional 17.4%, factor 3(2 questions) explained an additional 6.3%, and the total instrument accounted for 78.1% of the variance. There was a distinct discrimination score of 10.3 to identify people who have the minimally accepted criteria for FAI. Test-retest reliability $ICC_{2,1}$ ranged from 0.69 (SEM=1.09) to 0.95 (SEM=0.42) for the items. Reliability was 0.81(SEM=2.21) for factor 1, 0.94 (SEM=1.06) for factor 2, 0.83 (SEM =1.01) for factor 3, and 0.92 (SEM=2.76) for the overall quest-ionnaire. Results of validity testing identified statistically significant correlation between the IdFAI and LEFS (p=-0.38, p<.01). **Conclusions:** The IdFAI is a simple, moderately valid, and reliable questionnaire that can be used to categorize an individual's FAI status. The IdFAI was specifically designed to detect individuals with FAI in both a clinical and a research setting and can be used to help ensure that subjects meet a minimum set of criteria for FAI.

The Relationships Between Three Commonly Used Ankle Instability Questionnaires

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Context: Chronic ankle instability (CAI) is a common condition following lateral ankle sprain. There is currently disagreement on how to best classify and rate degree of ankle instability. The Cumberland Ankle Instability Tool (CAIT), Foot and Ankle Disability Index (FADI) and the FADI Sport (FADI-S) are commonly used tools to differentiate between those with and without CAI. **Objective**: To determine the relationships between three frequently used ankle instability measures. **Design**: Correlational. **Setting**: Biomechanics Research Laboratory. **Patients or Other Participants**: Twenty-four recreationally active participants (15 females, 9 males, mean age ± standard deviation 22.3±3.8 years, height 173.33±8.67 cm, mass 77.15±14.17 kg). Participants reported either no history of ankle sprains, a previous moderate-severe sprain from which they had no residual symptoms of instability, or a history of moderate-severe sprain which resulted in residual symptoms of instability. **Interventions**: Participants completed the CAIT, FADI and FADI-S in a single test session. Data were assessed to make sure it met all statistical assumptions. Upon review it was deemed necessary to use non-parametric, correlational tests to determine significant correlations between the three tests (α<.01) based on violating the assumption of normality. **Main Outcome Measures**: CAIT scores were calculated out of a possible 30 points for the right and the left legs. The FADI was calculated as a percentage of a possible 104 points, while the FADI-S as a percentage out of a possible 32 points. Higher scores indicated improved ankle joint function. The involved limb or test limb from the FADI and FADI-S was matched to its respective side for the CAIT, therefore only 1 limb was assessed for each participant. Non-parametric Kendall's tau correlational

tests were used to assess data based on a small sample size with a number of tied ranks. **Results**: Two subjects' data were excluded due to being statistical outliers. The average CAIT score was 25.27±4.88. For the FADI and FADI-S the average percentages were 98.59±2.46 and 93.27±8.66, respect-ively. There were statistically sign-ificant relationships among the three scores, CAIT and FADI (tau=.533, p=.001), CAIT and FADI-S (tau=.563, p<.001) and FADI and FADI-S (tau=.721, p<.001). **Conclusions**: The CAIT correlated moderately with the FADI, and slightly higher with the FADI-S, while the FADI and FADI-S were strongly correlated. While the CAIT addresses similar aspects of self-report ankle function in daily and some sporting activities to the other questionnaires, the moderate corre-lation indicates the two tests may be capturing different components or constructs of perceived ankle function. The FADI and FADI-S also seem to address slightly varying constructs as their correlation coefficient, while strong, was not exceptionally high. Therefore, it may be important to utilize multiple questionnaires to capture a more complete picture of self-reported ankle function.

Ankle Dorsiflexion Predicts Self-Reported Disability in Patients with Acute Ankle Sprains

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

Context: Lateral ankle sprain is the most common lower extremity injury in sport. Acute lateral ankle sprains are associated with increased pain, disability, and increased risk of developing chronic ankle instability. The presence of decreased ankle dorsiflexion range of motion (ROM) has been demonstrated in patients with chronic ankle injury and has been hypothesized to contribute to long-term functional impairments and disability. Unfortunately, little is known about how ankle dorsiflexion ROM is related to disability in patients with acute lateral ankle sprains. **Objective:** Determine the relationship between ankle dorsiflexion and self-reported disability in patients with an acute lateral ankle sprain within the first 36 hours following injury. **Design:** Descriptive. **Setting:** Clinical Laboratory. **Patients or Other Participants:** Eleven patients with acute lateral ankle sprain volunteered for this study (8 Females, 3 Males, 21.2±1.3yrs, 173± 11.7cm, 75±18kg, grade I sprains=4, grade 2 sprains=7). All patients were individuals from the University community. **Interventions:** Patients reported to a Certified Athletic Trainer and consented to participate within the first 36 hours of injury. The same Certified Athletic Trainer evaluated each patient with a standardized form and graded each ankle sprain. The Foot and Ankle Disability Index (FADI) questionnaire was administered to quantify self-reported disability. Scores were reported as a percentage of full function (100%), with lower scores indicating decreased perceived function or increased ankle disability. Active ankle dorsiflexion was measured in long-sitting position with the injured ankle extending off of the edge of a padded plinth. Patients were instructed to dorsiflex the injured ankle as far as they could comfortably reach. The end range was quantified in degrees using a goniometer, with greater values indicating increased dorsiflexion ROM. The mean of 3 trials was recorded. The same investigator performed all measures. **Main Outcomes:** Our outcome measures included percentage scores from the FADI (69.72±17.70%), and ankle dorsiflexion ROM measured in degrees (9.35º±2.02º) at 36 hours post-injury. A Pearson Product Moment correlation was performed and squared to determine the relationship between FADI and ankle dorsiflexion and to evaluate the variance in dorsiflexion that accounts for variance in the FADI in patients with acute ankle sprains. Alpha levels were set *a priori* at P≤0.05 **Results:** Ankle dorsiflexion significantly predicted self-reported ankle disability within the first 36 hours post-injury ($r=0.68$, $R^2=0.47$, $P=0.02$). **Conclusion:** Following acute ankle injury, dorsiflexion ROM appears to be a good indicator of self-reported disability related to activities of daily living. Our data suggests that decreased dorsiflexion is related with poor self-reported disability in the initial 36 hours post lateral ankle sprain. Dorsiflexion ROM predicted 47% of the variance on the FADI questionnaire. Clinicians may consider focusing on early efforts to increase dorsiflexion ROM in effort to improve perceived disability following acute ankle sprains.

Physical Activity and Functional Knee Outcomes in Active Young Females with Anterior Knee Pain

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Context: The ability to maintain desired physical activity (PA) levels and knee function are essential for long-term health and fitness. While there has been significant attention on surgical outcomes and return to sport in anterior cruciate ligament injury among young females, there is little information on the outcomes associated with chronic knee injury. The use of self-report instruments to measure the impact of structural and functional impairments associated with sports injuries on knee function and physical activity of high school and collegiate athletes is limited. The 2000 International Knee Documentation Committee (IKDC) Functional Knee Scale is widely used to assess knee function and the International Physical Activity Questionnaire (IPAQ - short form) is a valid measure of self-reported physical activity. Gathering objective measures on knee function and physical activity in active young females can aid in assessing the impact of chronic injury on these two components of long-term health. **Objective:** Describe one year

changes in physical activity levels and knee function in a cohort of young females with anterior knee pain. **Design:** Prospective cohort. **Settings:** Data were collected at a sports medicine clinic and university health service. **Participants:** A convenience sample of 65 high school and college females (age = 17.8 ±1.6 years) who were diagnosed by a physician with anterior knee pain (AKP) that was a result of participation in sport or regular fitness activities. **Interventions:** Knee function was assessed with the 2000 IKDC knee survey (IKDC). Self-reported PA levels were measured using the International Physical Activity Questionnaire (IPAQ – short form). Knee function and self-reported PA levels were assessed pre-injury, at diagnosis, and 12 months postinjury. **Main Outcome Measures:** Outcome variables included the paired differences in the IKDC and PA scores (MET-min/week) from pre-injury to 12 months post-injury. Paired differences were assessed with paired T-Tests ($p < 0.05$) reported as the mean + SD. **Results:** IKDC scores at 12 months (-8.8 + 17.0) were significantly lower than preinjury scores ($p < 0.001$). IPAQ PA scores (MET-min/week) at 12 months were significantly lower than pre-injury levels for vigorous (-1682, + 3194; $p<0.001$) and total (-1862, + 4731; $p<0.006$) activity. **Conclusions:** Active females with anterior knee pain demonstrated lower knee function scores and had lower levels of vigorous and total physical activity one year after onset of injury. Sports medicine providers need to be aware that anterior knee pain can impact knee function and desired activity levels for up to one year following onset. Measuring knee function and physical activity may provide clinicians and researchers with a more authentic outcomes assessment.

Changes in Quadriceps Corticospinal Excitability Correlate with Changes in Knee Flexion Angle during Stair Descent Following an Experimental Knee Joint Effusion

Murray AM, Lepley AS, Bahhur NO, Armstrong CW, Gribble PA, Pietrosimone BG: University of Toledo, Toledo, OH

Context: Knee joint injury often results in neuromuscular quadriceps dys-function, resulting in altered lower extremity gait patterns and kinematics. Growing evidence suggests that quadriceps corticospinal excitability is influenced following knee injury, possibly leading to quadriceps dysfunction and gross motor deficits. However, the relationship between corticospinal changes in neuromuscular function and changes in joint kinematics following acute injury remains unknown. **Objective:** Investigate the relationship between changes in quadriceps corticospinal excitably and changes in knee joint flexion angle at initial contact (IC) during a stair descent following an experimental knee joint effusion used to simulate acute joint injury. **Design:** Descriptive labo-ratory study. **Setting:** Research labo-ratory. **Patients or Other Participants:** Eight healthy parti-ipants (5M/3F; 20.9±1.7yrs; 172.4 ±7.1cm; 68.8 ±8.2kg) volunteered. **Interventions:** Corticospinal excita-bility of the vastus medialis was tested in the left limb. Participants were outfitted with 26 retroreflective markers and performed three trials of stair descent on a custom built staircase at a self-selected pace. Following baseline testing, 60mL of sterile saline was injected into the knee joint capsule of each participant through an area supralateral to the patella. Ten minutes following effusion participants performed posttest measurements. **Main Outcome Measures:** Quadriceps corticospinal excitability was evaluated using the amplitude of peak-to-peak motor evoked potentials (MEP) in the vastus medialis, elicited using Transcranial Magnetic Stimulation (TMS) and collected with surface electromyography. Prior to collecting peak-to-peak MEPs, participants performed knee extension at 5% of their maximal capabilities while an active corticospinal motor threshold was determined as the lowest TMS intensity that elicited a measurable vastus medialis (>100μV) MEP in five out of ten consecutive trials. Five MEPs were evoked at 130% of threshold, and peak-to-peak values were averaged and normalized to maximal Muscle Responses, which were elicited by electrically stimulating the femoral nerve. Knee flexion angle was measured through 3-dimensional motion analysis and was extracted at IC using the Visual-3D processing system. IC was defined as the first 25% of stance phase, which was initiated once ground reaction forces exceeded 10Nm. Percent change values following effusion were calculated for MEP and knee flexion angles [(post-pre)/pre)*100]. A non-parametric Spearman rank correlation was performed to assess the relationship between change scores of corticospinal quadriceps excitability and knee flexion angle. Alpha level was set *a priori* at $P \leq 0.05$. **Results:** A significant, negative and strong correlation was found between change scores of MEPs and knee flexion angle (ρ=-0.714,P=0.047). **Conclusions:** There was a strong and negative correlation between change in corticospinal excitability and knee flexion angle. This suggests that individuals may up-regulate cortico-spinal excitability in order to maintain similar knee flexion angles during daily activities, such as stair descent, following acute knee injury. Interventions targeting corticospinal excitability following knee injury may be beneficial in maintaining pre-injury knee joint kinematics. *Supported by funding through the Great Lakes Athletic Trainers' Association.*

Relationship Between Corticospinal Excitability and Muscle Activation of the Quadriceps following an Experimental Knee Joint Effusion

Lepley AS, Murray AM, Bahhur NO, Gribble PA, Pietrosimone BG: University of Toledo, Toledo, OH

Context: Altered quadriceps cortico-spinal excitability and voluntary quadriceps activation is associated with various knee pathologies. It is hypothesized that upstream neural changes in corticospinal excitability may influence gross downstream neuromuscular changes in voluntary activation. Unfortunately, due to the retrospective nature of the current available research, the relationship between upstream and downstream changes in neuromuscular function immediately following acute injury is unknown. Artificially effusing the knee joint with sterile saline can provide a model to simulate acute knee injury, allowing for investigation of these relationships. **Objective:** Investigate the relationship between changes in quadriceps corticospinal excitably and changes in voluntary quadriceps activation following an experimental knee joint effusion. **Design:** Descriptive laboratory study. **Setting:** Research laboratory. **Patients or Other Participants:** Eight healthy participants (5M/3F; 21.3±2.05yrs; 172.4±7.1cm; 69.9±9.38kg) volunteered. **Interventions:** Vastus medialis corticospinal excitability and voluntary activation were tested in the left limb in a random order. Following baseline testing, participants were positioned supine with their left knee slightly flexed in preparation for knee effusion. An area supralateral to the patella was cleaned and 3mL of 1% Xylocaine was subcutaneously injected for local anesthetic purposes. Via a supralateral approach, 60mL of sterile saline was injected into the knee joint capsule. Following effusion, participants rested quietly for 10 minutes prior to post-testing. Percent change scores were

calculated from pre and post measurements for both corticospinal excitability and muscle activation. A nonparametric Spearman rank correlation was performed to assess the relationship between change scores of corticospinal quadriceps excitability and voluntary quadriceps activation. Alpha level was set *a priori* at P≤0.05. **Main Outcome Measures:** Quadriceps corticospinal excitability was evaluated with motor evoked potentials (MEP) derived using Transcranial Magnetic Stimulation (TMS) while participants performed knee extension at 5% of their maximal capabilities. Initially, a threshold was determined by finding the lowest TMS intensity that elicited a measurable (>100μV) MEP response in five out of ten consecutive trials. For analysis, five MEPs were evoked at 110% of threshold. MEP peak-to-peak values were averaged and normalized to maximal Muscle Responses, which were elicited by electrically stimulating the femoral nerve. Quadriceps activation was determined by using the central activation ratio (CAR) obtained through the burst superimposition technique. Percent change scores were calculated for MEP and CAR values [(post-pre)/pre)*100]. **Results:** A significant, negative strong relationship was found between change scores of MEPs and CAR (p=-0.762,P=0.028). **Conclusions:** There was a strong negative correlation between changes in quadriceps corticospinal excitability and muscle activation. These results suggest that in order to maintain voluntary quadriceps activation following acute knee injury, individuals may need to make large compensations in corticospinal excitability. Therefore, interventions targeting corticospinal excitability may be beneficial in restoring voluntary quadriceps activation. *Supported by funding through a grant from the Great Lakes Athletic Trainers' Association.*

Ankle Cryotherapy Does Not Affect Hoffmann Reflex Modulation of the Soleus and Peroneus Longus in Patients with Chronic Ankle Instability

Kim KM, Hart JM, Saliba SA, Ingersoll CD, Hertel J: University of Virginia, Charlottesville, VA; Central Michigan University, Mount Pleasant, MI

Context: Altered Hoffmann (H) reflex modulation during changes in body positions was recently found in patients with chronic ankle instability (CAI).. Ankle cryotherapy has been found to influence H-reflex amplitudes in the ankle muscles, yet its effects on H-reflex modulation are unknown. **Objective:** To assess the effects of a 20-min ankle cryotherapy on H-reflex modulation of the peroneus longus and soleus in three body positions (prone, bipedal, and unipedal stances) in individuals with and without CAI. **Design:** Descriptive laboratory study. **Setting:** Laboratory. **Patients or Other Participants:** Fifteen subjects with CAI (9 males, 6 females; age= 23±5.8 years; height=174.7±8.1cm; mass= 74.9±12.8kg) and 15 controls without any history of ankle sprains (9 males, 6 females; age=24±5.8 years; height =171.9±9.9 cm; mass=68.9±15.5 kg) participated. **Interventions:** Independent variables were group (CAI, control), intervention (ankle cryotherapy, sham), and time (before and after the treatment). Subjects in both groups underwent two intervention sessions on different days in which they had a 1.5L plastic bag filled with either crushed ice (active treatment) or candy corn (sham intervention) applied to the ankle. Maximum H-reflexes (H_{max}) and motor waves (M_{max}) from the soleus and peroneus longus were recorded while subjects lied prone and then stood in quiet bipedal and unipedal stances before and after each treatment. **Main Outcome Measures:** H_{max} was normalized to M_{max} to obtain H_{max}:M_{max} ratios for the three positions. Dependent variables, for each muscle, were the percent change scores in H_{max}:M_{max} ratios between each pair of positions: prone-to-bipedal (P-Bi), bipedal-to-unipedal (Bi-Uni), and prone-to-unipedal (P-Uni). Separate three-way (Group x Intervention x Time) ANOVAs with repeated measures and Fisher's LSD were performed for statistical analysis. **Results:** The CAI group was responsive to both interventions in Bi-Uni and P-Uni modulation, but there were no differences between cryotherapy and sham treatments. The ankle cryotherapy did not affect the soleus modulation in any of the 3 positional changes. Specifically, for the soleus P-Bi modulation, there was a significant group main effect (P=.001). The CAI group (12.6±6.4%) modulated less than the healthy group (37.3±5.9%). For the soleus Bi-Uni modulation, there was a significant group by time interaction (P=.049). The CAI pre-intervention modulation (-12.9±5.5%) was significantly less than the CAI post-intervention (1.8±9.2%), healthy pre-intervention (2.3±5.1%), and healthy post-intervention (-2.1±8.5%) modulation. Similarly, a significant interaction was found in the soleus P-Uni modulation (P=.005). The CAI pre-intervention modulation (12.4±5.7%) was significantly less than the CAI post-intervention (29.2±6.8%), healthy pre-intervention (41.6±5.0%), and healthy post-intervention (39.5±6.1%) modulation. For peroneus longus, there were no significant interactions or main effects (P>.05) for any of the three positional modulations. **Conclusions:** A 20-min ankle cryotherapy was not found to influence H-reflex modulation of the peroneus longus and soleus in any of the three postural transitions in individuals with and without CAI.

Evidence of an Integrated Lower Extremity Motor Excitability Relationship to Ankle Laxity in Patients with Chronic Ankle Instability

McLeod MM, Gribble PA, Pietrosimone BG: University of Toledo, Toledo, OH

Context: Gross neuromuscular alterations have been demonstrated in ankle stabilizing muscles and proximal muscle groups of patients with chronic ankle instability (CAI). It is hypothesized that these neuromuscular alterations may be attributed to a need to compensate for increased laxity at the ankle. Recent evidence suggests that these gross neuromuscular deficits may be modulated by both reflexive and corticospinal pathways. It is critical to understand the relationship between ankle laxity and motor excitability in patients with CAI for the purpose of directing specific interventions. **Objective:** Determine the relationship between ankle inversion/eversion (IE) laxity and corticospinal and reflexive excitability of the fibularis longus (FL) and vastus medialis (VM) in patients with severe CAI. **Design:** Descriptive. **Setting:** Research laboratory. **Patients or Other Participants:** A cohort of 14 patients with severe unilateral CAI [Functional Ankle Disability Index-Sport (FADISportτ) ≤66 out of 100%] volunteered in this study (7F/7M, 20.6±1.7yrs, 171.8± 12.1cm, 66.9± 11.0kg, FADISport: 52±10.51%). **Interventions:** Involved-side IE ankle laxity was quantified in degrees with an instrumented arthrometer, with larger measures indicating increased laxity. Corticospinal excitability of the FL and VM was measured in a seated position using transcranial magnetic stimulation (TMS) to elicit motor evoked potentials (MEP) stimulated at the motor cortex and visualized via electromyography at the target muscle. Active motor threshold (AMT) was determined bilaterally for each muscle at the lowest TMS intensity that elicited a measurable MEP (>100mV) in 5 out 10 consecutive trials. Reflexive excitability was evaluated bilaterally using a brief exogenous electrical stimulus over the tibial or femoral nerve to evoke a Hoffmann reflex in the FL or VM, respectively. An electrical stimulus was used to evoke a maximal muscle response (M-Response) in both the FL and VM for normalization. **Main Outcome Measures:** Corticospinal excitability was evaluated as the average of five peak-to-peak MEPs at 120% of AMT normalized to a M-response (MEP:M) in all muscles. Maximal Hoffmann reflexes were normalized to M-Responses (H:M) for all muscles. Separate Pearson Product Moment correlations were used to determine the relationship between involved ankle IE laxity and bilateral reflexive and corticospinal excitability in the FL and VM. Alpha level was set *a priori* at P≤0.05. **Results:** A significant and strong, positive correlation was found for involved IE laxity and involved reflexive FL excitability (r=0.75, P=0.003). Additionally, a significant moderate positive correlation was found between involved IE laxity and uninvolved VM cortical excitability (r=0.66, P=0.014). No further significant correlations were detected. **Conclusions:** As IE laxity of the involved ankle increases, reflexive excitability of the involved FL and corticospinal excitability of the contralateral MV also increase. This may be indicative of a global neuromuscular protective mechanism to cope with increased laxity and prevent future inversion ankle sprains. *Supported by funding through the University of Toledo Interdisciplinary Grant.*

Optimal Stimulation Parameters to Detect Deficits in Quadriceps Activation

Grindstaff TL, Threlkeld AJ: Creighton University, Omaha, NE

Context: The burst superimposition technique is used to estimate quadriceps activation, but is often associated with discomfort due to electrical stimulus intensity. It is unknown if stimulation parameters can be manipulated to minimize discomfort while obtaining valid estimates of quadriceps activation. **Objective**: To determine optimal stimulation parameters to detect deficits in quadriceps activation and quantify discomfort associated with simulation parameters. **Design**: Descriptive laboratory study. **Setting**: University research laboratory. **Patients or Other Participants**: Twelve healthy adults (mean±SD, age=36.8±15.6 years, mass=76.1±12.9 kg, height=170.2±8.6 cm). **Interventions**: Participants were seated on an isokinetic dynamometer. A constant current stimulator and two self-adhesive electrodes (8x14 cm) delivered percutaneous electrical stimuli to the quadriceps. Resting twitch torque (RT) was determined by increasing stimulus intensity in 100 mA increments until RT plateaued. Repeated maximal volitional isometric contractions (MVIC) were performed while imposing four stimulation combinations: train of higher voltage stimuli (10 pulses; 400V) with variable current (based on RT); train of lower voltage stimuli (10 pulses; 200V) with variable current (based on RT); train of lower voltage stimuli (10 pulses 200V) at set current (650 mA); a doublet of lower voltage stimuli (2 pulses, 200V) with set current (650 mA). Eight stimuli (2 of each combination) were randomly applied with 2 minutes rest between each MVIC. **Main Outcome Measures**: Quadriceps activation was quantified using two equations, central activation ratio (CAR=MVIC/MVIC+electrical) and percent activation (%Act=[MVIC-MVIC+electrical]/RT). Discomfort was quantified using the visual analog scale

(VAS). Pearson product moment correlations were used to determine the relationship between stimulation parameters and quadriceps activation equations. Differences in discomfort during RT and MVIC parameters were determined using separate one-way ANOVAs. **Results**: Means and standard deviations for quadriceps activation and VAS relative to each stimulation parameter were; higher voltage 10-pulse variable current (CAR=.80±.15; %Act=.69±.23; VAS RT=6.3±2.0; VAS MVIC=4.6±2.2), lower voltage 10-pulse variable current (CAR=.79±.18; %Act=.69±.24; VAS RT=6.1±1.6; VAS MVIC=4.7±2.5), lower voltage 10-pulse set current (CAR=.81±.16; %Act=.71±.24; VAS RT=6.7±2.2; VAS MVIC=5.3±2.4), and lower voltage doublet set current (CAR=.91±.12; %Act=.80±.24; VAS RT=2.9±1.7; VAS MVIC=2.2±1.6). Correlations for all measures were strong (r=.85 to .99, P< .001). There was a significant difference in VAS RT ($F_{3,33}$=25.1, P< .001) and VAS MVIC ($F_{3,33}$=20.0, P< .001). The lower voltage set current (650 mA) using a doublet produced less discomfort during the RT (P< .001) and MVIC (P< .001) when compared to all other combinations using a train of stimuli (10 pulses). There were no significant differences (P> .05) in discomfort among the other parameters. **Conclusions**: There was a strong correlation between all combinations and equations utilized to estimate quadriceps activation. Adjusting the number of pulses (2 versus 10) reduced discomfort by more than 50%, while eliciting %Act values that correlated well (r>.90) with activation levels obtained with more pulses.

Free Communications, Thematic Poster: Functional Testing and Movement Screening

Friday, June 29, 2012, 11:45AM-1:15PM, Room 275; Moderator: David Bell, PhD, ATC, CSCS

Influence of Static Lower Extremity Alignment on Joint Kinematics During the Overhead Squat Test in Adolescent Athletes

Nguyen A, Boling MC, Varone AN, Buckley BD, Keene KL, DiStefano LJ: College of Charleston, Charleston, SC; University of North Florida, Jacksonville, FL; University of Connecticut, Storrs, CT

Context: Efficient functional screening tools are commonly used during prospective risk factor studies to help identify and understand those factors that increase the risk of knee injuries. Understanding factors that may contribute to dynamic malalignments during functional tasks will help us better identify those at greatest risk of injury, particularly in the adolescent athlete, where intervention may be most effective. **Objective:** To determine the influence of static lower extremity alignment (LEA) on hip and knee kinematics during the overhead squat test in adolescent athletes. **Design:** Cross-Sectional. **Setting:** High school athlete screening. **Patients or Other Participants:** Forty-five male (15.6 ± 1.3yrs, 177.9±8.4cm, 72.0±11.7kg) and twenty-five female(15.8 ±1.1yrs, 165.3 ±8.4 cm, 59.2±9.3kg) adolescent athletes volunteered as part of a larger, multi-center risk factor screening project. **Interventions:** Clinical measures of pelvic angle (PA), genu recurvatum (GR), and navicular drop (ND) were measured during three trials on the dominant limb by a clinician with known reliability ($ICC_{2,k}$>0.87). Tibiofemoral angle (TFA) and Q-angle (QA) were assessed using an electromagnetic tracking system. All LEA measures were recorded to the nearest degree or centimeter. Three-dimensional kinematics of the hip and knee were assessed on the dominant limb during five consecutive overhead squats. **Main Outcome Measures:** Hip and knee peak joint angles were extracted during the descent phase (start to maximum knee flexion) of each overhead squat trial. LEA values were averaged over three measurements and peak joint angles were averaged over the five overhead squat trials. Separate step-wise linear regressions determined the extent to which static LEA predicted hip and knee joint angles for males and females. **Results:** In males, greater TFA (12.5±4.8°) predicted less hip flexion (-92.5 ±21.7°, R^2=0.097, *P*= 0.037) but greater knee flexion (96.6±11.9°, R^2=0.100, *P*= 0.034) during the overhead squat. Greater QA in males predicted less hip internal rotation (-1.8±9.8°, R^2=0.135, *P*= 0.013) but greater knee valgus (-10.3 ±3.7°, R^2=0.099, *P*= 0.035). In females, no static LEA variables contributed significantly to hip and knee kinematics during an overhead squat test (*P*>0.05). **Conclusions:** While static LEA has been suggested to contribute to an increased risk of knee injuries, our findings suggest that static LEA contributes minimally to dynamic malalignments during an overhead squat test, particularly in the adolescent female athlete. These findings suggest that differences in joint angles at the hip and knee when performing the overhead squat test may be more dependent on neuromuscular or other anatomical factors. Ongoing research will examine whether differences in hip and knee kinematics during the overhead squat and static LEA independently increase the risk of knee injuries in adolescent athletes.

Supported by University of North Florida Faculty Development Research Grant

Relationship Between Functional Assessments in Patients with Knee Pathologies

Radtke AR, Howard JS, Morris LM, Mattacola CG: University of Kentucky, Lexington, KY

Context: Patient performance on functional tests is often used to monitor progress throughout the recovery process and release patients from rehabilitation. In order for a test to effectively monitor patient progress over time, it must be able to detect differences in performance between varying levels of pathology. **Objective:** To determine whether patients with varying levels of function will perform differently on the unilateral stance, step up/over, forward lunge, four square step test (FSST), star excursion balance test (SEBT) and the step-down test. We hypothesized that pre-operative patients would perform worse than healthy individuals for all tests except unilateral stance. **Design:** Observational cross-sectional study. **Setting:** Controlled, laboratory setting. **Patients or Other Participants:** 15 (5F,10M) pre-operative knee patients between the ages of 18-60 (30.4±10.2 yrs, 181.3±10.1 cm, 196.8±40.9 lb) and 13 (6F, 7M) healthy individuals (31±11.6 yrs, 173.1±10.5 cm, 171±34.4 lb) with no current history of lower extremity injury or previous history of lower extremity surgery. **Interventions:** Patients performed the unilateral stance, step up/over, forward lunge, FSST, SEBT and step-down test. Unilateral stance, step up/over and forward lunge were performed on the NeuroCom Long Force plate (NeuroCom, Clackamas, OR). The FSST, SEBT and step-down test were performed without the force plate. All single-leg assessments were performed on the dominant or uninjured limb first. Testing order between force plate assessments and clinical assessments was counterbalanced between subjects.

Unpaired T-tests ($p<.05$) were used to compare performance between healthy individuals and pre-operative patients. **Main Outcome Measures:** For the unilateral stance, mean center of gravity sway velocity (deg/s) was measured. For the step up/over, movement time (s) was measured. Forward lunge was measured in distance (% Height) and time (s). The average time of completion for the FSST was used in statistical analysis. The SEBT was measured in the average reach distance (% leg length). The step-down test was measured in number of complete repetitions within 30 seconds. **Results:** Healthy patients (1.2s) completed the step up/over task faster than pre-operative patients (1.7s, $p=.005$) for the injured limb. When performing the forward lunge on the injured limb, healthy patients (53.2 % Height) reached further than pre-operative patients (44.9 % Height, $p=.001$) and healthy patients completed the forward lunge faster (1.01s) than pre-operative patients(1.38s $p=.005$). On the FSST, healthy patients (6.3s) performed faster than pre-operative patients (7.8s, $p=.043$). Healthy patients performed more repetitions (18.9) during the step-down test for the injured limb than pre-operative patients (10.9, $p=.018$). There were no differences in unilateral stance or SEBT between groups. **Conclusions:** Our findings indicate that the step up/over, forward lunge, FSST and step-down tests can effectively detect differences in function, and therefore, may be useful in monitoring patient progress, especially early on in the rehabilitation process.

Relationship between Functional Exercise Assessments and Balance Changes Following Exercise

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Context: The Functional Movement Screen (FMS™) consists of seven separate tests during which an examiner assigns a grade (0-3) to assess mobility, stability, balance and coordination during functional movements. The composite score from the FMS™ has been used as a screening tool for injuries among firefighters and football athletes. Since the test is administered at rest, it is unknown whether its scores change in response to exercise. Balance often deteriorates with exercise or fatigue and is associated with injury risk. Therefore by understanding the relationship between FMS™ scores and exercise-relate balance deficits clinicians may better understand the potential prognostic qualities of the FMS™. **Objective:** To correlate FMS™ scores measured in a rested state to changes in static balance following exercise, and secondly, to compare FMS™ scores before and after exercise. **Design**: Descriptive laboratory study. **Setting**: Laboratory. **Patients or Other Participants**: Twenty-seven healthy and recreationally active individuals voluntarily participated (22.0±3.1yrs, 170.2±10.2cm, 67.9±18.1kg). Participants had no history of musculoskeletal surgery, no injuries in the previous 6 months, and exercised at least three times per week for at least 30 minutes per session. **Interventions**: Two testing sessions occurred over two days. The first session, consisted of a familiarization session for the FMS™ test. The second session took place 24-48 hours of the first session. During this session, baseline measures of the FMS™ and balance were recorded. For balance, subjects stood on a forceplate for three, 10-second trials while maintaining hands on hips and eyes closed. Participants then performed 36 minutes of continuous aerobic and anaerobic exercise. The exercise intervention consisted of repeated cycles of 5-minutes of incline treadmill walking and 1-minute of explosive jumping exercises. Outcome measures were repeated immediately after exercise. **Main Outcome Measures**: Center of pressure (COP) standard deviations (SD) in the medio-lateral (M-L) and antero-posterior(A-P) planes, COP velocity, COP area, and FMS™ composite score ™ were compared from before to after exercise using t-tests and Wilcoxon rank tests as indicated. Spearman rho correlation coefficients were used to determine relationships between FMS™ and changes in static balance after exercise. **Results**: Static balance measures were significantly altered after exercise. Specifically, A-P standard deviation (Pre=1.5±0.4cm, Post=1.8±0.5cm, $t=-3.0$, $p=0.01$)and COP-Area(Pre=33.1±12.3cm^2, Post=43.5±18.2cm^2, $t=-2.9$, $p=0.01$) significantly increased after exercise. The composite FMS™ score did not significantly change after exercise (pre=16[15-17]; post=16[15-16], $p=0.24$). There were no significant correlations observed between FMS™ score and change in static balance after exercise. **Conclusions**: The FMS™ score measured in a rested state is not related to changes in static balance occurring after exercise therefore may not be helpful in identifying injury risk related to static balance deficits. The FMS™ score is not sensitive to changes that occur following 36-minutes of continuous aerobic and anaerobic exercise.

Functional Performance Measures of NCAA Division I Football Players by Position

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Context: Deficits in functional performance have been cited as possible risk factors for injury including decreased trunk muscle endurance and movement asymmetry. However, the lack of sport specific normative data limits the clinical value of functional performance measures. With improved normative data, at risk individuals can be better identified and allow for more targeted performance and injury prevention interventions. **Objective:** To determine if differences exist in the functional performance of NCAA football players by position. **Design:** Comparative analysis. **Settings:** Biomechanics research laboratory. **Participants:** 103 uninjured NCAA Division I collegiate male football players (age = 19.3± 1.03 years, mass= 105.19±19.26 kg, height= 186.4±7.35 cm). **Interventions:** A compre-hensive functional performance assessment was completed prior to one regular season consisting of trunk endurance measures, single leg hop distance, single leg anterior reach distance, and deep squat performance. **Main Outcome Measures:** The independent variable of player position was dichotomized into linemen (n=26) vs. non-linemen (n=62). Dependent variables were deep squat performance (categorized 0-3), single leg hop for distance (SLHOPd), single leg anterior reach (SLAR) and trunk endurance times for extension and left and right side bridge. Trunk extension to side bridge symmetry ratios were expressed as the percentage of the left or right bridge over extension. Side bridge, SLHOPd and SLAR symmetry ratios were expressed as a percentage of the longer time or longer distance. SLHOPd was normalized to percentage of leg length (%LL) and to hop work (Newtons*meters (N*m). SLAR was normalized to leg length (%LL). Linemen and non-linemen comparison was achieved via independent samples t-tests with an *a priori* alpha level of .05. **Results:** Trunk extension time was significantly (p= .001) lower for linemen (85.13±28.6 s) vs. non-linemen (108.5±29.92s). Both side bridge times were significantly (p=.04) lower for linemen (left: 66.65±33.79s; right: 65.47 ±33.41) vs. non-linemen (left: 83.03±33.49s; right: 81.63±32.53s). Linemen also had significantly (p<.001) lower SLHOPd leg length (left: 190±22%LL; right: 204± 22%LL) vs. non-linemen (left: 239±24%LL; right: 245±24%LL). But linemen had significantly (p<.001) higher SLHOPd work (left: 2452.52 ± 309.17 N*m; right: 2563.07 ±274.43 N*m) vs. non-linemen (left: 2206.99±248.68 N*m; right 2236.69 ±279.52 m/kg). SLAR, squat per-formance, trunk endurance ratios and SLAR and SLHOPd symmetry ratios were not significantly different between the two groups. **Conclusions:** Study results indicate trunk endurance and SLHOPd performance is lower among football linemen. Accounting for body mass the linemen produce more work during the SLHOPd even though they didn't jump as far. This corroborates other findings that mass should be taken into consideration when conducting functional performance testing. The decrease in trunk endurance may also be partly attributed to the increased mass. Given the small sample size further study is needed to determine the clinical value of these tests on risk of injury.

Functional Movement Screen Comparisons Between Pubertal Levels in Male Youth Lacrosse Players

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Context: The Functional Movement Screen (FMS) has been developed to screen for dysfunctional movement patterns. Currently, information is lacking as related to pubertal stages within the adolescent population. **Objective**: To determine whether whole body dysfunction patterns identified by the FMS will differ between pubertal groups in youth male lacrosse players. **Design**: Quasi-experimental. **Setting**: Controlled Laboratory. **Participants**: 30 youth male lacrosse players who were free of lower extremity injury at time of participation were grouped according to their pubertal level: pre-pubertal (Pre)(N=8;age =9.9±1.1yrs; height= 137.3±8.8cm;mass=32.7±7.1kg), pubertal (Pub)(N=12;age=11.4±0.9 yrs; height =152.3± 10.7cm;mass =44.3±11.0kg), and post-pubertal (Post)(N =10;age =12.9±0.7yrs; height=164.6± 5.3cm;mass =51.9± 7.4kg). **Interventions**: Parents and partici-pants filled out the modified Pubertal Maturation Observational Scale to determine pubertal group. The participants performed the 7 tests of the FMS: Deep Squat(DS), Hurdle Step(HS), In-Line Lunge(ILL), Shoulder Mobility(SM), Active Straight Leg Raise(ASLR), Trunk Stability Push-Up(TS), and Rotary Stability(RS) tests. A Kruskal-Wallis test was utilized to assess differences between groups, as well as frequency distributions to assess the asym-metries (asymm)(p<.05). **Main Outcome Measure(s)**: The dependant variables included the Total FMS Score(TotSc) and individual test scores [DS;HS;ILL;ASLR;SM;TS;RS]. The inde-pendent variable was pubertal level (pre, pub, post). **Results**: No statistically significant differences were found in FMS scores between pubertal levels for any of the measures

(p=.21-.94). However, 50% of the subjects displayed ≥ 1 asymm between-side scores, and there were 21 total asymm noted. The Pub group displayed the highest frequency of asymm(66.6%) followed by the Post(50%) and the Pre(25%) groups. The SM produced the highest number of asymm(38.1%) followed by the HS(23.8%), ILL(19.0%), ASLR (14.3%), and TS(4.8%). The raw data demonstrated that the HS did not have any scores of (1) reported for any subject; but, it was also the most difficult task to receive a score of (3) for all groups followed by the DS. The Post had the least amount of (3)'s for the ASLR. Additionally when compared to the TotSc using a cut-off score of ≤14, it was found that for both the DS and ILL, no subject that had a TotSc of ≤14 achieved a score of (3) on either test; in addition, none of those that had a TotSc of ≥15 received a score of (1) or below on either of these tests. Lastly, 86% of those falling below the "cut-off" score of ≤14 demonstrated ≥ 1 asymm; whereas, only 39% of those above the cut-off displayed any asymm. **Conclusions**: No significant findings of FMS scores were found between male pubertal groups; although, it was observed that the pubertal group experienced more side-to-side asymm when compared to the other two groups. Further observation may suggest that the DS, ILL scores, and having ≥ 1 asymm may aid in determining whether the TotSc is above or below the previously determined cut-off score for risky patterns.

The Functional Movement Screen™ as a Predictor of Ankle and Knee Injuries in Female Collegiate Athletes

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Context: Previous investigations suggest the Functional Movement Screen (FMS™) may provide strong predictive capabilities for lower extremity injury in some male athletes, but little information exists to establish the effectiveness of injury prediction among female collegiate athletes. **Objective:** To determine the capability of the FMS™ to predict lower extremity injury in collegiate female basketball, soccer and volleyball players. **Design:** Prospective cohort. **Setting:** Athletic training clinic. **Patients or Other Participants:** Fifty-five Division I women's basketball, soccer and volleyball players (19.45±1.15yrs; 173.0±8.47cm; 68.0±9.66kg) volunteered. **Interventions:** Prior to their 2010 respective seasons, all participants performed all seven stations of the FMS™ (deep squat, hurdle step, in-line lunge, shoulder mobility, active straight leg raise, trunk stability push-up, and rotary stability). Certified Athletic Trainers (ATC) recorded acute ankle and knee injury occurrences during the competitive seasons. After the season, players were stratified into an injured or non-injured group depending on the recordings by the ATC's. **Main Outcome Measures:** Each station of the FMS™ is scored on a 0-3 scale, with a total possible composite score of 21 points indicating a perfect performance. Independent samples t-tests were used to detect differences between the groups (injured, non-injured) for the composite score. Effect sizes (Cohen's d) with 95% confidence intervals (CI) were calculated using pooled standard deviations. Significance was set at $P<0.05$. Receiver-operator characteristic curves were used to determine the FMS™ composite score that maximized specificity and sensitivity. Additionally, positive and negative likelihood ratios (+LR and -LR) and odds ratios were calculated. **Results:** Thirteen participants (23.6%) experienced acute lower extremity injuries. For the FMS™ composite score, there was no statistically significant Group difference ($t_{1,55}=1.68$; P=.100; d=0.52; 95%CI: -0.11, 1.15; Injured:16.08±1.12; Non-Injured: 16.86±1.56). A FMS™ composite score of 16.5 was associated with a sensitivity of 0.62 and a specificity of 0.74(+LR=2.35, -LR=0.52). This resulted in an odds ratio of 4.50. **Conclusion:** While no significant differences in FMS™ composite scores were found between participants that incurred an acute lower extremity injury and those that did not, the FMS™ composite did demonstrate good sensitivity and specificity. Our data showed that female collegiate athletes that scored <16.5 on the FMS™ composite were 4.5 times more likely to suffer a traumatic lower extremity injury. Clinicians can consider using the FMS™ composite as a predictor of traumatic ankle and knee injuries for collegiate female basketball, soccer and volleyball players. This may be important for identifying athletes that may benefit from intervention before the season begins.

Star Excursion Balance Test As a Predictor of Ankle and Knee Injuries in Collegiate Football Athletes

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Context: Poor performance on the Star Excursion Balance Test (SEBT) has previously been found to predict ankle and knee injuries in adolescent athletes, but little information exists to establish the effectiveness of injury prediction among collegiate football athletes. **Objective:** To determine the capability of the SEBT to predict lower extremity injury in collegiate football players. **Design:** Prospective cohort. **Setting:** Athletic training facility. **Patients or Other Participants:** Ninety-two, NCAA Division I football players (age:19.60 ±1.29yrs; height: 186.84±6.51cm, mass:101.96 ±18.84 kg), medically cleared for sport participation, volunteered. **Interventions:** Prior to the 2010-2011 football season, dynamic postural control was measured bilaterally in collegiate football players using the anterior, posteriormedial, and posteriorlateral directions of the SEBT. Reach distances were recorded in centimeters and expressed as a percentage of the stance limb length (%MAXD). During the season, a Certified Athletic Trainer recorded time lost from traumatic ankle and knee injuries. **Main Outcome Measures**: At the end of the competitive season, athletes were stratified into an injured (traumatic ankle or knee; n=18) or uninjured (n=74) group, accordingly. The normalized means and standard deviations of the anterior, posteriormedial, posteriorlateral and composite (an average of the three directions) reaches were compared between the groups. Independent t-tests were utilized to compare the four reach scores between the affected side of the injured group and randomly selected side of the uninjured group. Statistical significance was set *a priori* at ≤.05. Using a receiver operating characteristic curve analysis, sensitivity and specificity of the performance scores were calculated to rule out and rule in the injured and uninjured participants. Positive and negative likelihood ratios were then calculated to create odds ratios separately for each reach direction. **Results:** For group differences in all directions, the injured group had lower scores compared to the non-injured group, but all comparisons were not statistically significant. However, the anterior reach comparison was nearly significant (t_{90}=-1.92, P=.058; Uninjured: 72.84±6.74%, Injured: 69.21±8.90%). The anterior reach score seemed to have the best prediction capability. An anterior reach score< 68.0% was associated with moderate sensitivity (0.56) and strong specificity (0.81), with an odds ratio of 5.37. **Conclusions:** The results of the study demonstrate that the SEBT may provide a tool for screening collegiate football players at risk for traumatic ankle or knee injuries during the competitive season. Focusing on the anterior reach score, players with a normalized score less than 68% were greater than 5 times more likely to have suffered a traumatic ankle or knee injury. With continued investigation and application, clinicians and researchers may be able to utilize dynamic postural control measured with the SEBT as a predictive tool to identify collegiate football athletes at risk for suffering an ankle or knee injury.

Hip Strength Ratios and Lower Extremity Injury in NCAA Division I Soccer Players

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Context: Weak hip musculature has been identified as a factor in lower extremity injury; however, not all individuals exhibiting muscle weakness experience injury. **Objective:** The purpose of this study was to examine strength ratios of the hip musculature between college soccer players who did and did not suffer lower extremity injuries. **Design:** Cohort study. **Settings:** Movement analysis laboratory. **Participants:** 382 NCAA Division I collegiate soccer players; 200 male (179.6 ± 6.7 cm, 76.6 ± 7.8 kg, 19.5 ± 1.3 years) and 182 female (167.4 ± 6.0 cm, 62.7 ± 7.1 kg, 19.3 ± 1.1 years). **Interventions:** Peak isometric hip and knee strength was measured prospectively using a portable load cell (BTE Technologies, Hanover, MD). Frontal and sagittal plane motions were measured in the standing position; transverse plane rotations were measured in the seated position. Peak isometric knee strength was measured in the seated position. Peak strength values were arranged into four strength ratios: hip flexion:extension (FLX:EXT), abduction:adduction (ABD:ADD), external:internal rotation (ER:IR), knee extension:flexion (EXT:FLX). Ratio values were obtained by dividing peak strength of the agonist muscle by peak strength of the antagonist. **Main Outcome Measures:** Athletes were followed prospectively for two consecutive seasons. Each team's ATC recorded all injuries. Athletes were then classified as either "injured" (n=136) or "non-injured" (n=178) for the purpose of this analysis. Lower extremity injury was defined as any event affecting the lower limb, originating at the hip and extending distally, that caused

participation time loss for one or more days. Independent samples *t*-tests were conducted, with an *a priori* alpha level of 0.05, in order to determine if differences in strength ratio asymmetries were present between athletes who did and did not sustain a lower extremity injury. **Results:** A significant difference in strength ratios, with respect to lower extremity injury, was reported for one of the four calculated strength ratios: (Hip FLX:EXT p=.026, Hip ABD:ADD p=.270, Hip ER:IR p=.893, Knee EXT:FLX p=.154). Average (mean ± sd) strength ratios were: Hip FLX:EXT injured (117.9 ± 43.9%) and non-injured (108.8 ± 28.2%); Hip ABD:ADD injured (84.3 ± 36.0%) and non-injured (80.5 ± 23.4%); Hip ER:IR injured (109.7 ± 28.6%) and non-injured (110.1 ± 30.9%); Knee EXT:FLX injured (93.8 ± 30.7%) and non-injured (98.6 ± 28.5%). **Conclusions:** The results of this study show a significant difference between hip flexion:extension strength ratios for injured versus non-injured athletes. A greater amount of hip flexion strength comparative to hip extension may cause an imbalance in the lower extremity resulting in increased injury occurrence. Future lower extremity injury studies may benefit from focusing on hip musculature imbalances during the pre-season, rather than singularly focusing on knee strength.

Massage Potentiates Cell Survival Mechanisms in Healthy Skeletal Muscle Through the Activation of Autophagy

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Context: Although muscle trauma initiates an inflammatory response that often results in secondary hypoxic injury, autophagy is a cell signaling pathway that promotes cell survival. Through the selected removal of damaged organelles, such as mitochondria, autophagy can act as an alternative pathway to apoptosis and necrosis, thereby reducing cell death and maintaining cellular function following injury. Targeting this pathway utilizing manual therapies has not been addressed to date, and may prove beneficial following muscle injury. Because massage is a commonly utilized manual modality for the treatment of inflammation and muscle pain, we have developed a cyclic compressive loading (CCL) paradigm to use a massage mimetic for controlled laboratory testing. We have previously been shown CCL to enhance the recovery of force and modulate the infiltration of inflammatory cells in eccentrically exercised muscle. **Objective:** Investigate the influence of moderate magnitude of CCL on autophagy markers in healthy skeletal rat muscle. **Design:** Experimental design utilizing basic science methodologies in physiological systems. Therefore, alpha was set 'a priori' at 0.10. **Setting:** This experiment was performed within a controlled laboratory setting. **Participants:** Consisted of 6 Male Wistar Rats (200g). **Interventions:** Subjects were placed in one of two groups massage (4.5N load, n=3) or control (0.0N load, n=3). Those receiving treatment underwent CCL (frequency of loading 1Hz) for 30 minutes for 4 consecutive days to the left Tibialis Anterior (TA). Control rats were anesthetized and positioned, but not massaged. On day 5, left TA muscles were extracted and frozen for analysis. Tissue samples were homogenized and western blot analysis was performed. Membranes were probed for autophagy marker BCLN1 and actin was used as a protein loading control. Membranes were scanned and analyzed using an Odessey Licor system. BCLN1 band intensity was measured in relation to actin and statistical analysis was performed using SPSS version 19. **Main Outcomes:** Muscle expression (in arbitrary units of density, AU) of BCLN1 protein in massaged and control tissues were compared with Student's t-test. **Results:** 4.5N CCL resulted in a significant increase in the expression of BCLN1 protein compared to control rat TA muscle (0.112±0.004AU vs. 0.097±0.017AU, respectively, p=0.56). **Conclusions:** Although we have previously shown that massage in the form of CCL attenuates the inflammatory response and facilitates recovery of muscle function following damaging eccentric exercise, the mechanisms remain unknown. Here we have shown that only 4 days of applied massage in the form of CCL results in an increased activation of cell survival pathways, likely reducing cell stress and limiting cell damage and subsequent necrosis. Further work is ongoing in our laboratory to continue to uncover mechanisms belying the efficacy of massage.

Foam Rolling Prior to Stretching Increases Hamstring Flexibility

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Context: Foam rollers are commonly used prior to stretching. Many athletes report that foam rollers help release tension in their muscles thus resulting in greater range of motion (ROM) when used prior to stretching. To date, no investigators have examined the influence of foam rollers and static stretching. **Objective**: To determine if a standard foam rolling protocol prior to static stretching increases flexibility of the hamstring muscle group. **Design:** Descriptive laboratory study. **Setting**: Applied Musculoskeletal and Human Physiology Research Laboratory. **Patients or Other Participants:** Forty subjects (male: n=14, age=21.29±2.58yrs, ht=176.62±5.28cm, mass= 73.96± 16.9kg; female: n=26, age=21.08 ±2.91yrs, ht= 167.05±6.19cm, mass=73.62±11.52kg) with less than 90° of hip flexion ROM and no lower extremity injury in the 6 months prior to the study participated. **Interventions:** A 2x4x6 factorial design guided data collection. Independent variables were time (pre and post), condition ((static stretching (SS), foam rolling and static stretching (FR/SS), foam rolling (FR), and control (nothing)) and day (1, 2, 3, 4, 5, 6). To minimize accessory movement, hip flexion ROM was performed by having subjects lay supine with a strap placed across their hip and the uninvolved leg. A bubble inclinometer was then aligned on the thigh of the involved leg where subjects then performed active hip flexion 3 times. Subjects randomly assigned to the SS group received 3 one-minute static stretches with a 30-second rest between each stretch. Those in the FR and FR/SS sat on the

foam roller supporting their body weight with their arms. Subjects then actively rolled the foam roller from their ischial tuberosity to the popliteal fossa. Subject then returned to the table where hip flexion ROM measures were again taken 3 times. **Main Outcome Measures**: The dependent variable was hip flexion ROM before and after each treatment on each day. **Results:** There was a significant interaction between group and time ($F_{3,16}$=7.20; P< .003). Hip flexion ROM increased over the 6 days in the SS, FR, and FR/SS groups (Tukey-Kramer, P<.05). Subjects in the FR/SS condition increased hip flexion ROM more than those in the SS, FR, and control groups (FR/SS pre: 77.88±15.85; post: 86.85±16.58; SS pre: 70.68±11.27; post: 78.09±11.86; FR pre: 77.80±12.11; post: 82.19± 12.37; Tukey-Kramer, P<.05). **Conclusions**: Our results support the use of a foam roller in combination with a static stretching protocol. If time allows and maximal gains in hip flexion ROM are desired, foam rolling the hamstrings prior to static stretching would be appropriate in non-injured patients who have less than 90° of hamstring ROM.

The Impact of an Acute Bout of Static or Dynamic Stretching on Flexibility, Performance, Strength and Soreness in High School Athletes.

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Context: Sports healthcare professionals have long advocated pre-exercise stretching to increase flexibility, enhance performance, and prevent injury. While many have investigated the benefits of stretching, the impact of stretching on high school athletes is poorly studied. **Objective:** To compare the acute effects of static (SS) and dynamic stretching (DS) on flexibility, vertical jump, strength and soreness in high school athletes. **Design:** Repeated measures. **Setting:** High school athletic training room. **Participants:** 39 healthy high school male and female athletes (16.8±1.3 yrs, height 179.1±9.8cm, weight 77.6±17.4 kg) from a conven-ience sample. **Interventions:** Subjects were divided into 3 groups: SS, DS and control (CON). All subjects completed a brief medical history form, a 2 minute warm-up, and underwent pre and post-testing for flexibility using a sit-and-reach box, vertical jump performance using a vertec, strength using a handheld dynamometer, and soreness using a numeric pain rating scale. The SS and DS groups completed approximately 10 minutes of lower extremity static (5 stretches) or dynamic (5 stretches) stretching, with each stretch performed 3 times for 30 seconds with a 15 second rest between sets. The CON group rested for 10 minutes. **Main Outcome Measures:** The dependent variables included flexibility (cm), vertical jump performance (cm), hamstring strength (ppsi), and soreness (0=no soreness, 10=significant soreness). All measurement techniques have reported acceptable reliability and validity, and intra-rater reliability was established for the handheld dynamometer (intraclass correlation coefficient=.88). A 2(time) X 3(group) repeated measures analysis of variance was run for each dependent variable. Means and standard deviations were calculated for all variables, and significance was noted at P<.05. **Results:** We found no significant interactions between group and time on any of the outcomes: flexibility (CON: pre=29.1±2.4, post=30.4±2.4; SS: pre=28.9±2.6, post=31.4±2.6; DS: pre=29.8±2.5, post=32.0±2.5, P=.14), jump performance (CON: pre=282.6±5.4, post=282.0±5.3; SS: pre=286.4±5.9, post=286.6±5.7; DS: pre=288.0±5.6, post=288.9±5.5, P=.55), strength left leg (CON: pre=55.6±2.5, post=53.2±2.5; SS: pre=50.6±2.7, post=50.8±2.7; DS: pre=56.1±2.6, post=56.7±2.6, P=.38), strength right leg (CON: pre=54.9 ±2.5, post=53.4±2.4; SS: pre= 51.5 ±2.6, post=50.8±2.6; DS: pre= 54.9 ±2.5, post=54.2±2.5, P=.92), and soreness (CON: pre=.71±.39, post =.86±.47; SS: pre=1.3±.42, post= 1.7±.50; DS: pre=1.5±.41, post= 1.4±.48, P=.48). There was a significant main effect for time in regards to flexibility (pre=29.2±1.5, post =31.3±1.4, P<.001). No significant main effects for time were noted for jump performance (P=.81), left (P=.57) or right (P=.30) leg strength, or soreness (P=.33). **Conclusion:** These results suggest that an acute bout of static or dynamic lower extremity stretching may not produce a meaningful improvement in lower extremity flexibility, jump performance, or strength in high school athletes. Our results are in contrast to research reported in adults. Adolescent athletes may respond differently to stretching than older populations, although more research in this area is warranted. Future studies should exam whether longer-term stretching programs positively impact adolescent flexibility and per-formance.

Increased Forefoot Inversion During Walking Gait in Individuals with Functional Ankle Instability

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Context: Functional ankle instability (FAI), a common sequela to ankle sprain, can limit physical activity and activities of daily living (ADL) for years post-injury. One ADL that may be affected by instability is walking gait. Different forefoot and hindfoot movement patterns between individuals with and without FAI during gait may partially explain reports of instability. **Objective**: The purpose was to capture ankle and foot kinematic data during walking gait among FAI, copers and healthy individuals. **Design**: 3 group observational cross-sectional design. **Setting**: Sports Medicine Research Laboratory. **Participants**: Participants included 23 individuals with a history of at least 1 ankle sprain and at least 2 episodes of giving-way in the past year (FAI, Cumberland Ankle Instability Tool [CAIT]=20.52±2.94, episodes of giving-way=5.81±8.42 per month), 23 subjects with no history of ankle sprain or instability in their lifetime (controls, CAIT=28.78±1.78), and 23 individuals with a history of a single ankle sprain and no subsequent episodes of instability (copers, CAIT=27.74±1.69). Subjects were matched for age, height and weight (age=23.3±3.8years, height=1.71±0.09m, weight= 69.0± 13.7kg). **Interventions**: Ten trials of natural walking gait were recorded using a ViconMX motion capture system (Oxford, UK) and two Bertec force plates (Columbus, Ohio). **Main Outcome Measures**: During walking forefoot and hindfoot sagittal and frontal plane angles at initial contact (IC) and toe-off (TO) were calculated using the Oxford foot model. For each variable at each time point we used separate one-way ANOVAs to compare groups (α=.05). For post hoc testing, we used 3 Bonferroni adjusted pairwise comparisons (α=0.0167). **Results**: For the forefoot in the frontal plane, there was a significant group difference at IC ($F_{2,66}$=4.68, p=0.013; control=-2.17±3.56°,coper=-0.51± 2.85°, FAI = 0.66±3.03°). Post hoc testing at IC, revealed that individuals with FAI were significantly more inverted than controls (mean difference= -2.84°, 95% CI=-4.70, -0.98),but copers were not significantly different from the FAI or control groups (coper-FAI: mean difference= -1.17°, 95% CI= -3.04, 0.69; control-coper: mean difference=-1.67°, 95% CI= -3.53, 0.20). There were no other significant group differences for forefoot or hindfoot motion (FOREFOOT: sagittal plane IC: $F_{2,66}$=0.16, p=0.849, frontal plane TO: $F_{2,66}$=1.63, p=0.204, sagittal plane TO: $F_{2,66}$=1.10, p=0.338; HINDFOOT: frontal plane IC: $F_{2,66}$=0.59, p=0.556, frontal plane TO: $F_{2,66}$=0.62, p=0.541, frontal plane TO: $F_{2,66}$=0.62, p=0.541, sagittal plane TO: $F_{2,66}$=3.08, p=0.052). **Conclusions**: We found increased forefoot inversion at IC in individuals with FAI. Previously, increased inversion error in individuals with FAI has been thought to partially explain symptoms of instability. However, we found a similar amount of inversion in copers, despite the fact that they do not suffer from instability. This may indicate that increased forefoot inversion does not contribute substantially to instability, that there is an inversion threshold effect, or that copers mediate instability through some other mechanism.

The Reliability and Responsiveness of Gait Initiation Profiles in Those with Chronic Ankle Instability

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Context: Individuals with chronic ankle instability (CAI) have demonstrated alterations in gait initiation (GI) when compared to healthy individuals. While these differences provide important information about sensorimotor deficits associated with CAI, the intersession reliability of the GI profile remains unknown in this population. **Objective:** To determine the intersession reliability of GI measures between two testing sessions in those with CAI. **Design:** Reliability study **Setting:** Laboratory **Patients or Other Participants:** Twelve individuals with self-reported CAI (6 females and 6 males, age =27.4 ±4.5yrs, height=175.4± 10.8cm, weight= 78.4±12.1 kg, Foot and Ankle Ability Measure Sport: 58.6±11.1%) If a subject reported bilateral CAI, the self-reported worse limb was tested. **Interventions:** Subjects performed barefoot gait initiation on a force plate which captured center of pressure (COP) data sampled at 500Hz and low pass filtered at 10 Hz. The subjects were instructed to stand with feet shoulder width apart on the force plate. When given an audible cue, they were instructed to take their initial step with the uninvolved limb and then continue to walk down a pathway at a self-selected speed. Data was collected on two separate sessions separated by 1 week. **Main Outcome Measures:** The GI profile was separated into three phases (S1, S2, and S3) based on relevant changes in COP excursions. S1 began from the deviation of normal standing balance to the most posterolateral displacement under the stepping limb. S2 began from the end of S1 to the maximum lateral position

under the stance foot. S3 began at the end of S2 and continued until the vertical ground reaction force dropped below 100N; the moment when the stance foot left force plate. COP displacement (cm) was calculated as the sum of resultant vectors of the medial-lateral and anterior-posterior excursions for adjacent COP data point within each phase. The averages of 5 trials of COPdisplacements for each phase were used for analyses. Intraclass correlation coefficients (ICC) and standard error of measurements (SEM) were calculated to determine the reliability of the measures between Session 1 and Session 2. Lastly, the minimum detectable change (MDC) was calculated for each phase. Alpha-level was set a-priori at p>0.05. **Results:** The results indicate that S1 (Session 1=7.46±1.98cm, Session 2=7.91± 1.68cm, ICC(2,5)=0.84, SEM= 0.29cm, MDC=0.42cm, p=0.003), S2(Session 1=19.21±4.29cm, Session 2=20.06±2.92cm, ICC(2,5)=0.88, SEM=0.44cm, MDC=0.63cm, p= 0.001), and S3 (Session 1=16.08 ±1.49cm, Session 2=16.46±1.84cm, ICC(2,5)=0.93, SEM=0.12cm, MDC =0.17cm, p>0.001) displacement values were highly reliable between the 2 days of testing. **Conclusions:** The displacement measures across all GI phases demonstrated excellent intersession reliability with very small MDC values. This information is critically important to the understanding of anticipated responsiveness of GI profiles in those with CAI due to therapeutic interventions. Whether the GI profile is sensitive to change due to intervention in this population remains unknown.

Saggital Summary Kinematics During Walking Reveal Gait Alterations in Those with Chronic Ankle Instability

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Context: Gait alterations have been proposed to be contributing factors to chronic ankle instability (CAI). The majority of investigations have examined differences among individual joints of the lower extremity between those with and without CAI. By examining a clinically relevant summary of lower extremity joint behaviors during gait, it may be possible to elucidate the link between gait alterations and CAI. **Objective:** To determine if the summary profile of sagittal kinematic s during walking reveal significant alterations during walking gait in those with CAI. **Design:** Case-control study. **Setting:** Laboratory. **Patients or Other Participants:** Twelve adults with CAI (7 males, 5 females;age:25.9±3.4years; height: 176.5±8.8cm;weight: 80.3±13.6kg) and 12 adults with no ankle sprain history (7 males, 5 females; age:26.7±4.7years; height: 71.8±5.8cm; weight:72.5±9.7kg) participated. The CAI group reported 9.2±5.5 previous ankle sprains, 5.7±5.4 episodes of instability in the past 3 months, and Foot and Ankle Ability Measure Sport scores of 66.5±16.5%. Subjects were matched by side and involved limb. **Interventions:** All subjects walked on a treadmill instrumented with force plates at a speed of 1.5m/s. Three-dimensional kinematics of the lower extremity joints were captured for 30s using a 15-camera motion analysis system. Data were time normalized to 101 points from initial-contact (0%) to the subsequent initial-contact of the same limb (100%). **Main Outcome Measures:** Sagittal hip, knee, and ankle kinematics were calculated for 5 nonconsecutive gait cycles. Dorsiflexion, knee flexion, and hip flexion angular changes were represented as positive values (summary-flexion) whereas plantar-flexion, knee extension, and hip extension were negative (summary-extension). In addition, the peak vertical ground reaction force (vGRF) was calculated and normalized to body weight (N/kg) during stance phase. The ankle, knee, and hip sagittal kinematics were summed for each of the 101 stride points and group means ± standard error (SE) were calculated across all points. Periods of non-overlapping SE intervals were averaged and group means were compared using independent t-tests ($\alpha \leq 0.05$). **Results:** Two periods of non-overlap were identified between the CAI and control group. From 0-45% (CAI:17.0±6.5º, Control:23.5±6.6º, p=0.02) and from 72-100% (CAI:44.8±5.8º, Control: 53.5±6.4º, p=0.002) of the gait cycle, the CAI group displayed significantly less summary flexion values compared to the control group. The CAI group also demonstrated a trend toward higher peak vGRF (CAI: 11.93±1.34N/kg, Control: 11.17± 1.01N/kg, p=0.13), but it did not reach significance. **Conclusions:** The use of summary flexion and extension profiles of the hip, knee, and ankle revealed significant kinematic differences between those with and without CAI. These alterations may indicate that those with CAI have less of an ability to attenuate force upon impact based on less summary-flexion in the stance phase. The alterations in the latter part of swing phase may indicate a reduced ability to control limb placement in preparation for initial contact.

Effects of Chronic Ankle Instability and Ankle Bracing on Plantar Pressure Distribution During Jump-Landing

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Context: Previous investigation suggests that individuals with chronic ankle instability (CAI) exhibit more lateral plantar pressure during walking, which may increase the risk for inversion ankle sprain during gait. However, there is limited information quantifying these distributions during landing. Bracing is suggested to reduce risk of ankle injury, especially during jumping sports. It is unknown if bracing impacts plantar pressure distributions, which may be important for injury prevention. **Objective:** The purpose of this study was to examine the relationship of ankle bracing on plantar pressure distribution in subjects with CAI during a jump-landing task. **Design:** Case-control laboratory study. **Setting:** Research laboratory. **Patients or Other Participants:** Ten participants with CAI (6M, 4F; 21.2±1.7yr; 68.6±3.6cm; 167±23.9kg) and ten healthy participants (6M, 4F; 22.2±2.2yr; 69.9±3.7cm; 179.9±21.6kg), all physically active, volunteered. **Interventions:** Participants completed one testing session in which plantar pressure insoles were worn inside the shoe to quantify pressure distributions during performance of a jump-landing task with and without the application of an ankle brace. Three trials were performed under each condition, in a randomized order. The task consisted of a sub-maximal vertical jump (50% of maximum jump height) followed by a single-leg landing following. CAI participants landed on their involved limb, while the control participants landed on a selected matched limb. **Main Outcome Measures:** Peak plantar pressures from six regions of the landing foot were used to create three dependant variables: Forefoot Medial:Lateral pressure ratio, Midfoot Medial:Lateral pressure ratio, and Rearfoot Medial:Lateral pressure ratio. A value >1 indicated more medial pressure and a value <1 indicated more lateral pressure. For each dependant variable, a Group by Brace ANOVA was performed. Effect sizes (Cohen's *d*) with 95% con-fidence intervals were calculated using pooled standard deviations. Significance was set at P<.05. **Results:** There was a significant main effect for brace for the Midfoot Medial:Lateral pressure ratio ($F_{1,18}$=4.83; P=. 041), such that there was increased medial pressure without the brace (1.13±0.95) compared to with the brace (0.85±0.58). However, the effect size was small (*d*=0.35; 95%CI: -0.55,1.22). Similarly, for the Rearfoot Medial:Lateral pressure ratio, there was a significant main effect for brace ($F_{1,18}$=16.06; P=0.001) such that there was increased medial pressure without the brace (1.02±0.16) compared to with the brace (0.88±0.12); with a strong associated effect size (*d*=1.03; 95%CI: 0.06,1.91). All other comparisons were not statistically significant. **Conclusions:** Previous research shows increased lateral pressure during gait in CAI participants that is theorized to contribute to increased risk of injury. Our study suggests that plantar pressure may be distributed more medially during a landing task, but the application of a brace may translate peak pressures laterally. Additional research is needed to determine how bracing may be able to reduce ankle injury during dynamic tasks.

The Effects of Fatigue on Plantar Pressure Distribution During a Jump-landing Task in Participants with Chronic Ankle Instability

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Context: Chronic ankle instability (CAI), in conjunction with fatigue, has negative consequences on neuromuscular control. Limited investigation suggests there is an increased lateral distribution of plantar pressure during walking in CAI patients, which has implications for a mechanism of injury. There is limited information quantifying these distributions during landing. Additionally, the effect fatigue may have on these plantar pressures is unknown. **Objective:** The purpose of this study was to examine the effect of fatigue on plantar pressure distribution (PPD) in subjects with CAI during a jump-landing task. **Design:** Case-control laboratory study. **Setting:** Research laboratory. **Patients or Other Participants:** Ten physically active participants with unilateral CAI (6M, 4F; 21.2±1.7yr; 68.6±3.6cm; 167±23.9kg) and ten healthy participants (6M, 4F; 22.2±2.2yr; 69.9±3.7cm; 179.9±21.6kg) volunteered. **Interventions:** Participants completed one testing session that consisted of three jump-landing trials before and after a functional fatigue protocol. The jump-landing task consisted of a single-leg landing from a jump height equivalent to 50% of the participant's maximum vertical jump height. (50% $Vert_{max}$). CAI participants landed on their involved limb, while the control participants landed on an assigned matched limb. The functional fatigue task was comprised of three stations: Southeast Missouri Agility Drill, forward lunges and quick hops at 50% $Vert_{max}$. Participants performed the fatigue intervention until the time to complete the stations increased by 50% compared to their fastest time. Post-testing was performed immediately after a fatigued state was induced. Plantar pressure insoles were worn during pre- and post-testing to quantify the PPD during the landing trials. **Main Outcome Measures:** Peak PPD's of the landing foot were used to create three dependant variables: Forefoot Medial:Lateral pressure ratio, Midfoot Medial:Lateral pressure ratio, Rearfoot Medial: Lateral pressure ratio. A value of greater than 1 indicated more medial pressure and a value of less than 1 indicated more lateral pressure. Separate Group by Time ANOVAs were performed to evaluate the effects of fatigue on each dependant variable between the CAI and control

participants. Effect sizes (Cohen's d) were calculated using pooled standard deviations. Significance was set at P<.05. **Results:** There were no statistically significant Group by Time interactions for any of the variables: Forefoot Medial:Lateral pressure ratio ($F_{1,18}$=3.086; p=0.096), Midfoot Medial: Lateral pressure ratio ($F_{1,18}$ =0.001; p= 0.981), Rearfoot Medial:Lateral pressure ratio ($F_{1,18}$= 0.900; p=0.355). However, moderate-strong effect sizes suggest that pre-fatigue, peak pressures were more medially directed in the CAI group compared to the Control group in the forefoot (CAI: 1.67±0.88; Control: 1.15±0.26; *d*=0.80) and rearfoot (CAI: 1.07±0.19; Control: 0.98±0.13; *d*=0.77). **Conclusions:** CAI patients may have a different, perhaps more medial, PPD during a landing task. This is in contrast to previous research showing a more lateral PPD during gait. The discrepancies between studies may be attributed to task demand differences.

Difference in Landing Kinetics During Simulated Lateral Ankle Sprain Mechanism Between Chronic Ankle Instability and Healthy Participants

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Context: Many people develop chronic ankle instability (CAI) following a lateral ankle sprain. Altered landing kinetics, especially when the ankle is forced into inversion, may help explain the high recurrence rate. **Objective:** To determine if there is a difference in landing kinetics during a simulated lateral ankle sprain mechanism between participants with CAI and participants with no history of an ankle sprain. **Design**: Repeated measures design. **Setting:** Controlled laboratory setting. **Patients or Other Participants:** Twelve volunteers (age= 21.83 ±2.51years;mass=72.42±12.53kg; height=1.74±0.11m), which included 6 with CAI and 6 with no previous ankle injury/ sprain (NI). CAI participants had one moderate ankle sprain with a recurrent sprain within past 6 months and scored less than 90% on FADI and FADI-S. **Interventions:** The two independent variables were injury history (CAI, NI) and type of outer sole (fulcrum, flat). A fulcrum outer sole was placed on the bottom of the participants' shoe which forced the ankle into 25° of inversion upon landing from a 27 cm single leg step down. Participants were also tested with a flat outer sole. Ground reaction forces were measured with an AMTI force platform. Fourteen trials, seven with the fulcrum outer sole and seven with the flat outer sole were performed on the previously injured leg (CAI group) or matched control leg (NI group). Statistical analysis included a 2 x 2 ANOVA with repeated measures on outer sole condition to analyze the difference in landing kinetics between the injury and outer sole variables. **Main Outcome Measures:** The dependent variables were peak vertical and peak anterior/posterior ground reaction force (GRF), normalized to multiples of body weight (BW). Time to peak vertical GRF was also measured. **Results:** For peak vertical GRF, there was no significant interaction (*P*=.553). There was a significant main effect for injury history (NI=1.75±0.37 BW; CAI=1.38±0.17 BW; *P*=.034) and outer sole (fulcrum=1.43±0.31 BW; flat= 1.70±0.38 BW; *P*=.004). For peak anterior/posterior GRF, there was no significant interaction (*P*=.381). There was a significant main effect for injury history (NI=0.27±0.07 BW; CAI= 0.19±0.04 BW; *P*=.033) and outer sole (fulcrum=0.22±0.07 BW; flat=0.24±0.08 BW; *P*=.033). For the time to peak vertical GRF, there was a significant interaction between injury group and outer sole (*P*=.01), with the CAI group having a significantly greater time to peak with the fulcrum outer sole (148.0±51.6 ms) than the CAI group and flat outer sole (96.8±33.1ms), the NI group and fulcrum outer sole (97.8±33.9 ms), and the NI group and flat outer sole (94.2±29.4 ms). **Conclusions:** These differences in forces and loading times between the two groups may be an attempt by the CAI participants to change loading of the unstable ankle, and the altered landing kinetics potentially increase future risk of injury to the unstable ankle.

Shank-Rearfoot Coupling with Chronic Ankle Instability: A Vector Coding Variability Analysis

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Context: Altered joint coupling variability between tibial internal/ external rotation and rearfoot inversion/ eversion during gait may play a role in chronic ankle instability (CAI). **Objective**: We aimed to identify differences in the variability of shank-rearfoot coupling, as assessed with vector coding variability analysis, throughout the gait cycle between CAI and healthy control groups during barefoot and shod walking and jogging. **Design**: Case-control. **Setting**: Motion analysis laboratory. **Patients or Other Participants**: Twenty-eight physically active young adults (CAI, n=15, #previous ankle sprains=4.9±2.5; Control, n=13, #previous ankle sprains=0±0) participated. The Foot and Ankle Ability Measure (FAAM) and FAAM-Sport were used to identify the level of self-reported function of CAI subjects compared to controls (CAI,FAAM=92.1±5.8%, FAAM-S=74.8±13.3%, Control, FAAM= 100±0.0%, FAAM-S=100±0.0%). **Interventions**: Subjects walked (1.34m/s) and then jogged (2.68m/s) for 5 minutes each on an instrumented treadmill in both barefoot and shod conditions. **Main Outcome Measures**: Using a 12 camera motion analysis system, shank rotation and rearfoot inversion/eversion kinematic data were collected. Vector coding variability coefficients were calculated throughout the entire gait cycle for 3 consecutive strides using the Mullineaux method. This method estimates the between stride variability in coupling between 2 segments (in our case, shank rotation and rearfoot inversion/eversion) with a coefficient of 0 representing no variability and 1

representing complete randomness. At each speed and in both conditions, means and 90% confidence intervals were calculated for each group. Group differences were determined by identifying periods in the gait cycle where the confidence intervals did not overlap (therefore exact p-values were not generated in this analysis). Group means (±SD) were calculated across these intervals. **Results**: Group differences were identified from 76% to 78% of the gait cycle (CAI=0.31±0.04, Control=0.25±0.02) in barefoot walking, and from 37% to 59% in shod walking (CAI=0.10±0.01, Control=0.24±0.02). No group differences were found during barefoot or shod jogging. **Conclusions**: Our results indicate that individuals with CAI exhibit alterations in the variability of shank-rearfoot coupling during barefoot and shod walking, but not while jogging in either condition. During shod walking, the CAI group had less coupling variability during the swing phase compared to controls. Less variability could indicate a more constrained sensorimotor system. During barefoot walking, coupling variability was higher in the CAI group compared to controls which may indicate a less constrained sensorimotor system. The contrasting results between barefoot and shod walking illustrate the importance of environmental constraints on motor control variability. When the task constraint was increased from walking to jogging, subjects may have been forced into a more deterministic and predictable movement pattern regardless of health status, thus resulting in similar coupling variability between groups. Further research is needed to determine whether shank-rearfoot coupling variability is modifiable with interventions such as therapeutic exercise.

Explanatory Variables for Performance on the Anterior Reach of the Star Excursion Balance Test

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Context: The anterior reach direction of the Star Excursion Balance Test (ANTSEBT) has been shown to identify athletes at increased risk of suffering a lower extremity injury. Ankle dorsiflexion range of motion and postural control have been proposed to be explanatory variables for the performance on this test, but their relationships have not been clearly established in the physically active population. **Objective:** To determine whether ankle dorsiflexion and postural control are explanatory variables for performance on the ANTSEBT. **Design:** Correlation study. **Setting:** Athletic Training Room. **Patients or Other Participants:** Seventeen male and 11 female intercollegiate athletes (age:19.7±1.5 years, height: 175.4± 9.8cm, weight:64.1±10.6kg) participated in the study. All subjects were free from any lower extremity injury for at least 6 weeks. **Interventions:** All testing procedures were performed on both limbs of each subject. Subjects performed 3 trials of maximum reach in the ANTSEBT on each limb. The weight-bearing lunge test (WBLT) was used to measure DFROM. Subjects performed 3 trials of the WBLT in which they kept their test heel firmly planted on the floor while they flexed their knee to the wall. Maximum dorsiflexion was defined as the distance from the great toe to the wall based on the furthest distance the foot was able to be placed without the heel lifting off the ground while the knee was able to touch the wall. Each participant performed 4 practice trials of the ANTSEBT and 1 for the WBLT for each limb. ANTSEBT reach distance and WBLT distance were recorded in cm. In addition, all subjects performed the BESS single-limb stance test (SLBT) on a firm surface for 20 seconds. **Main Outcome Measures:** The mean of the 3 trials for each variable was calculated for each limb. Then the corresponding means for both limbs were pooled and used for analysis. Dependent variables included mean WBLT (cm), mean ANTSEBT reach distance (cm), and the number of errors for the SLBT. Pearson Product Moment correlation coefficients were calculated to examine the relationships among the WBLT, the ANTSEBT, and the SLBT. Alpha was set a priori at $p \leq 0.05$. **Results:** There was a significant correlation found for the WBLT (10.3±3.4cm) and the ANTSEBT (64.9±5.6cm), $r=0.59$, $r^2=0.35$, $p=0.001$). There were no significant relationships found between the SLBT (2.9±2.5 errors) and the WBLT ($r=0.14$, $r^2=0.02$, $p=0.46$) or the ANTSEBT ($r=0.13$, $r^2=0.02$, $p=0.52$). **Conclusions:** The ANTSEBT and the WBLT were significantly related and thirty-five percent of the variance in the ANTSEBT could be explained by the WBLT. Dorsiflexion is a strong explanatory variable for the ANTSEBT. Conversely, almost no variance could be explained in either measure by the SLBT. Although postural control is a known component of the ANTSEBT, it appears the SLBT captures a different aspect of postural control.

Self-Described Differences Between Legs in Ballet Dancers: Do They Relate to Postural Stability and Ground Reaction Force Measures?

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Context: Ballet technique classes are designed to train dancers symmetrically but they may actually create a lateral bias. Dancers are aware of this possibility and oftentimes claim to sense differences between their legs. It is unknown if dancers actually are functionally asymmetrical or how the dancer's perceived imbalances between legs manifest themselves. Presently, there are no studies focusing on functional asymmetry of dancers' legs that measure balance or ground reaction forces. **Objective:** To examine ballet dancers' lateral preference through analyzing their postural stability and ground reaction forces in fifth position when landing from dance-specific jumps. **Design:** Descriptive laboratory study **Setting:** Research laboratory. **Patients or Other Participants:** Thirty public university ballet majors volunteered to participate (23 females, 7 males; age: 19.6±1.1yrs.; height: 169.7±8.7cm; weight: 55.2±8.7kg). All subjects had no pre-existing conditions or injuries that would interfere with jumping or balancing ability. **Interventions:** Subjects wore ballet technique shoes and performed fundamental ballet jumps with one-footed- and two-footed-landings on a force plate. Each subject also completed a laterality questionnaire that determined the dancer's preferred landing leg for ballet, self-identified stronger leg, and self-identified leg with better balance. The questionnaire had good day to day reliability ($ICC_{(2,1)}$=0.79, SEM=0.65). All data were grouped according to the responses provided in the laterality questionnaire and all comparisons were made between the leg indicated on the questionnaire and the other leg (labeled "preferred leg" and "non-preferred leg," respectively). Data were analyzed using a multivariate repeated measures ANOVA. **Main Outcome Measures:** Ground reaction force(GRF) and center of pressure(COP) measures were analyzed separately. GRF measures included: maximal vertical GRF equalized to body weight(N/kg) and time to maximal vertical GRF(sec). COP measures included: anterior-posterior sway(cm), medial-lateral sway(cm), total COP excursion(cm), and average COP velocity(cm/s). **Results:** No significant differences were identified between the preferred and non-preferred leg in any of the analyses (p>.05). Specifically, there was no difference between the leg that was perceived stronger compared to the one that was not (p=.56, maximal GRF for preferred leg=2.32±0.31N/kg vs non-preferred leg=2.26±0.38N/kg; time to maximal GRF for preferred leg=0.13±0.02s vs non-preferred leg=0.12±0.02s). Additionally, there was no difference between the leg that was perceived to have better balance compared to the one that did not (p=.23, AP Sway for preferred leg= 9.46±2.67cm vs non-preferred leg= 8.28±2.84cm; ML Sway for preferred leg=11.52±4.16cm vs non-preferred leg=12.06±4.47; COP Length for preferred leg=61.93±9.02cm vs non-preferred leg=63.48±10.13cm; COP Velocity for preferred leg=6.55 ±0.89cm/s vs non-preferred leg=6.77 ±0.99cm/s). **Conclusions:** Interpretation of our results indicates that dancers' reported preferences seem to be separate from their actual ability. GRF absorption and balance ability in dancers do not seem to be influenced by: (1)which leg the dancer prefers to land with, (2)which leg the dancer feels is stronger, or (3)which leg the dancer feels has better balance.

Fibular Reposition Taping Facilitates Alpha Motoneuron Pool Excitability of the Soleus in Individuals with Chronic Ankle Instability

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Context: Arthrogenic muscle inhibition (AMI) has been observed in patients with chronic ankle instability (CAI). AMI prevents complete muscle activation, and may impede rehabilitation or strengthening efforts. Therefore, intervention strategies aimed at resolving AMI in individuals with CAI may have high clinical impact. Fibular reposition tape (FRT) has been described as a method used to improve outcomes in patients with ankle sprains. The influence of FRT on soleus and peroneus longus muscle function in patients with CAI is unknown. **Objective:** To compare soleus and peroneus longus muscle function after the application of FRT in individuals with CAI. **Design:** Crossover. **Setting:** Laboratory. **Patients or Other Participants:** Twelve subjects with CAI (3 males, 9 females; age=21.5±1.6 years; height =173.8±10.4cm; mass= 72.8±16.3kg) participated. **Interventions:** All subjects underwent two intervention sessions on different days at least one week apart. During each session, we performed 2 baseline measures spaced 5-minutes apart. Peak Hoffmann reflex (H_{max}) and Motor response (M_{max}) of the soleus and peroneus longus and Volitional (V) wave of the soleus were recorded to establish stability of baseline measures. Treatment (FRT, Sham) was applied via random assignment followed immediately by another measure of the H_{max}, M_{max}, and V-wave. The same examiner who was blinded to treatment recorded all outcomes, and a opaque sheet was used to blind the intervention during post-treatment measures. The FRT treatment consisted of a manual posterior glide of the lateral malleolus held by two

strips of non-elastic tape around the posterior aspect of the ankle. The sham session used the same tape configuration without posterior directed force. Individual 2x3 (Intervention X Time) ANOVAs with repeated measures followed by *post hoc* paired t-tests were performed for statistical analysis. **Main Outcome Measures:** The H_{max}/M_{max} ratios of the soleus and peroneus longus were calculated to represent alpha motoneuron pool excitability. The V/M_{max} ratios of the soleus were computed to indicate volitional activation during a maximal isometric soleus contraction. **Results:** There was a significant intervention X time interaction for soleus H_{max}/M_{max} ratio ($F_{2,22}$ =3.53, P=0.047) and pero-neus longus H_{max}/M_{max} ratio ($F_{2,22}$ =8.07, P=0.002) but not for the soleus V/M_{max} ratio ($F_{2,22}$ =0.99, P=0.39). The soleus H_{max}/M_{max} ratio was significantly higher after FRT (Pre=0.53±0.18, Post=0.59±0.17, t_{11}= -3.7, P=0.004), but not after Sham taping (Pre=0.55±0.21, Post=0.53 ± 0.18, t_{11}=1.7,P=0.12). Peroneal H_{max}/M_{max} ratio was higher after FRT taping (Pre=0.22±0.12V, Post=0.25±0.13V, t_{11}=-1.9, P=0.09) but did not reach statistical significance. Peroneal h:M ratio was not different after sham taping (Pre=0.33±0.23V, Post= 0.30±0.21V, t_{11}=1.4, P=.20). **Conclusions:** FRT was found to increase the soleus H_{max}:M_{max} ratio, but not the peroneus longus H_{max}:M_{max} ratio and the soleus V/M_{max} ratio. These results suggest FRT may be an effective modality in disinhibiting AMI in the soleus for individuals with CAI.

Muscle Activation during the Quadriceps Superimposed Burst Technique

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Context: The superimposed burst technique is commonly used to measure the extent of quadriceps activation via the central activation ratio (CAR). However, CAR has been reported to overestimate true quadriceps activation. This is possibly due to accessory muscle activation while measuring knee extension torque. **Objective:** To compare quadriceps, hamstring and lumbar paraspinal electromyographic (EMG)activation during the superimposed burst technique with and without technique based instruction. **Design:** Crossover, controlled laboratory study. **Setting:** Laboratory. **Patients or Other Participants:** Twenty-five healthy, recreationally active men and women (age= 23.8±3.4yr, height= 72.7±14.5cm, mass= 175.3±9.6kg). **Interventions:** Superimposed burst testing was conductedunder two testing conditions. During the participant preferred technique (PP), participants were permitted to use whatever means they wanted in order to achieve maximal knee extension torque. Participants were allowed to alter trunk angle (flexion, extension, and side-bending) and grip the stabilizing handles on the dynamometer chair without anyfeed-back from the investigator. During the verbal instruction technique (VI), verbal instructions directedthe participant to focus on quadriceps contraction, maintain upright posture with appropriate contact between trunk and back of the chair, and to exhale while contracting. **Main Outcome Measures:** Knee extension maximal volitional isometric contraction (MVIC) torque, quadriceps CAR and mean root mean square EMG of vastus lateralis, biceps femoris, and lumbar paraspinal muscles.CAR was measured using the *SIB* technique. While participants performed a knee extension MVIC, an electrical stimulus was triggered causing a transient increase in torque known as SIB torque. Mean MVIC torque was measured for the 100ms time epoch prior to the SIB and normalized to body mass. Quadriceps CAR was calculated as (MVIC/SIB)*100.Averagelumbar paraspinal, vastus lateralis and biceps femoris root mean square EMG activity was measured during the same time epoch used to measure knee extensiontorque and normalized resting EMG.Five separate paired samples t-tests were used to analyze differences between conditions for each dependent variable. **Re-sults:** Knee extension torque (VI= 2.87±0.93Nm/kg, PP= 3.40±1.12Nm/kg, P<0.001) and quadriceps CAR (VI=84.1±12.0%, PP=90.2±9.9%, P<0.001) were significantly greater in the participant preferred when compared to the verbal instruction technique. Lumbar paraspinal EMG was significantly greater (VI=6.4 ±8.5%, PP=11.9±14.9%, P=0.04) in the participant preferred technique when compared to verbal instruction technique, howeverthere were no differences in quadriceps EMG activation (VI=80.0±81.1%, PP=76.2± 79.3%, P=0.65) or hamstring EMG activation (VI=22.4±16.4%, PP= 22.0±19.2%,P=0.58). **Conclusions:** Greater knee extension torque and higher CAR values in the PP method may be related to higher EMG activity in the lumbar paraspinals. The use ofverbal instruction during the superimposed burst technique provides a standardized method for collecting knee extension MVIC and quadriceps CAR data with reduced hamstring and lumbar paraspinal muscle EMG activation but without reducing quadriceps EMG activation.

The Effect of Game Penalties on Head Impact Biomechanics in College Football Players

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Context: Rule changes in college football over the years have been established to help protect athletes from serious injury. Spearing and head-to-head contact penalties are designed to prevent unnecessary head trauma in college football. To date, objective quantitative biomechanical measures supporting these rules have been reported. **Objective:** To evaluate the effect of penalties on head impact biomechanics in college football players. We hypothesized head-related infractions would result in higher head linear acceleration, rotational acceleration, and severity profile measures. **Design:** Quasi-experimental prospective cohort. **Setting:** Field

setting. **Patients or Other Participants:** Forty-six Football Bowl Subdivision football players participated in our study (age=20.2±1.3yrs;height= 190.0±6.3 cm; mass= 106.6±18.8 kg). **Interventions:** Participants were equipped with accelerometer-instrumented helmets (Head Impact Technology System) to collect head impact biomechanics during all games in a single playing season. Multiple camera views were synchronized with the head impact data. We evaluated all viewable collisions (N=2345) using a standardized criteria rubric. Collisions were assigned as legal collisions or head-related infractions, which included spearing, head-to-head contact, and/or facemask. **Main Outcome Measures:** Dependent variables included head linear acceleration (measured in terms of gravity, g, force), head rotational acceleration (rad/s^2), and the Head Impact Technology severity profile (HITsp). The HITsp is a unitless composite measure factoring in linear acceleration, rotational acceleration, Head Injury Criterion, Gadd Severity Index, and impact location. Data were analyzed using separate random intercepts general mixed linear models for each dependent variable, incorporating each individual player as a repeating factor in the analyses. Only head impacts exceeding 10 g were included in our analyses. **Results:** Penalties involving head contact were observed in 4.5% (106 of 2345) of all football collisions. Overall, head collisions which should have resulted in penalties (31.4 g; 95% CI: 27.5-35.9) had higher linear accelerations than legal collisions (24.1 g; 95% CI: 23.4-24.8) ($F_{2,36}$=11.26; P<0.001). Likewise, these head-related collisions (18.5; 95% CI: 16.2-21.1) resulted in higher HITsp measures than the legal collisions (15.1; 95% CI: 14.6-15.6) we observed in our study ($F_{2,36}$=5.01; P=0.012). No significant differences in rotational acceleration between legal collisions and head-related collisions were observed in our study ($F_{2,36}$=2.13; P<0.133). **Conclusions:** Penalties involving head collisions result in higher linear acceleration and HITsp compared to legal collisions. Furthermore, approximately 1 in 20 collisions result from a spearing, head-to-head contact, and/or facemask penalty. Our results support the importance of strictly enforcing playing rules, and further lend support that existing rules are in place to protect the athlete from needless head injury. These data are equally important to guide athletes to understand the ramifications of their actions while playing, and for coaches to emphasize proper tackling techniques and skill development with their players.

The Effect of Maintenance on Hardware Removal Success in Used Football Helmets

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Context: The recommended method of removing the face-mask from the football helmet of an athlete with a suspected cervical spine injury is to first attempt to remove its attaching hardware. Hardware removal failures occur in used helmets, yet there is no research investigating prevention of these failures. **Objective:** To determine the effect of maintenance on the removal success rate of screws and Quick Release™ mechanisms and removal time of face-masks from high school football helmets that have been used for one or more seasons of play. **Design:** Cross-sectional. **Setting:** Field Study. **Participants:** 255 football helmets from seven high school teams in Alabama, USAused for a season or more of play;total of 510screws and 510 Quick Release™ mechanisms . **Intervention:** The helmets were divided into maintenanceand control groups (130 and125 helmets respectively). The maintenance grouped received mid-season maintenance consisting of functionally testing hardware, cleaning allhardware with soap and water, andreplacing hardwareas needed. The control group helmets received no maintenance.After the season facemasks were removed; screws were removed with a cordless screwdriver and Quick Release™ mechanismswere removed with a Quick Release™ tool. Data collectors were blinded to the helmet group during face-mask removal. **Main Outcome Measures:** Dependent variables were hardware and face-mask removal success rateand time (seconds). Face-masks that could not be removed within a minute were recorded as failures, and the contributing hardware was noted. An independent sample Chi-Square was used to compare removal success rates between the groups and variables. Timewas assessed with separate one-way Analysis of Variance. **Results:** Overall hardware removal success was significantly higher in the maintenance group (98.9%, 512/520) than the control group (89.6%, 448/500;$\chi^2(1) = 40.634$, $p < .001$). Quick Release™ mechanisms($\chi^2(1) = 4.726$, $p = .03$) and screws ($\chi^2(1) = 39.268$, $p < .001$) in the maintenance group had a significantly higher removal success than the control group. Face-mask removal success was also significantly higher in the maintenance group (95.38%, 124/130) than the control group (68%, 85/125; $\chi^2(1) = 32.322$, $p < .001$). The mean removal time of the 209 successful trials was 23.32 ± 7.64 seconds with no difference between groups. The mean number of exposures (practices or games) between maintenance and face-mask removal was 10.67 ± 2.34 exposures. **Conclusions:** Hardware maintenance increased the likelihood that the hardware could be removed. Although there were differences in screw removal success between schools and helmet model within the control group, screws in the maintenance group were unaffected by school or helmet model. Thus, our maintenance procedure increased the removal success rate of all hardware despitethese influencing factors.

Effects of Chronic Ankle Instability on Energy Dissipation in the Lower Extremity

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Context: Inadequate energy attenuation capability of the lower extremity joints during landing may influence lower extremity injury risk by increasing stress placed on static stabilizers. Previous investigations have demonstrated alterations in lower extremity kinematics and kinetics of patients with chronic ankle instability (CAI). However, energy dissipation patterns in the lower extremity have not been investigated in CAI patients. Understanding energy dissipation strategies in the lower extremity may assist in the development and implementation of more effective intervention protocols to modify alterations in the kinetic-chain relationship related to CAI. **Objective:** To investigate the influence of CAI on energy dissipation patterns in the lower extremity during a stop-jump task. **Design:** Case-control study. **Setting:** Research laboratory. **Patients or Other Participants:** Nineteen participants with self-reported CAI (9M, 10F; 20.21±1.69 yrs; 176.12±9.39 cm; 73.72±16.75 kg), and 19 healthy control participants (9M, 10F; 21.11±4.00 yrs; 170.51±9.12 cm; 70.86±15.15 kg) volunteered. **Interventions:** Participants performed 5 double-leg vertical stop-jump tasks onto a force plate. Kinetics and kinematics were examined with an electromagnetic tracking system interfaced with a non-conductive force plate. **Main Outcomes:** Lower extremity joint energy dissipations were calculated for the hip, knee, and ankle in the sagittal plane during 50ms, 100ms, and 200ms after initial contact (IC) with the force plate. Energy dissipation values were normalized to the product of body mass and height (J/N·m). Individual joint contribution to total lower extremity energy dissipation was reported as the percentage of energy dissipation by each joint over the total energy dissipation of all three joints; the ankle, knee, and hip. The control participants were matched by demographic information with CAI participants, and designated a matched limb for data analysis. Independent t-tests were used to assess differences in each dependent variable between the CAI and control groups. Cohen's *d* effect sizes with associated 95% confidence interval (CI) were calculated using the pooled standard deviations. Significance was set a priori at $P<.05$. **Results:** The CAI group demonstrated significantly less percentage of knee energy dissipation (CAI=18.65±9.57%, control =27.25± 16.09%, t_{36}=-2.00, P=0.05, *d*=-0.65, 95% CI: -1.29, 0.02) and higher percentage of ankle energy dissipation (CAI=54.18±18.91%, control =40.87 ±18.98%, t_{36}=-2.16, P=0.03, *d*=0.70, 95% CI: 0.03, 1.34) of the total energy dissipation during the 100ms immediately following IC compared to the control group. No significant differences for energy dissipations were found between groups at any of the joints during the 50ms and 200ms intervals. **Conclusion:** We found altered energy dissipation patterns at the knee and ankle during a stop-jump task in the CAI group. These findings may provide insight into kinetic alterations that may be associated with CAI. Future research should consider this information as it may be used to develop more effective interventions to target these potentially modifiable energy dissipation patterns in those with CAI. Supported by the NATA Foundation Master's Grant Program.

Lower Extremity Neuromuscular Function in Healthy and ACL Reconstructed Individuals Following a Sub-maximal Exercise Protocol

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Context: Persistent quadriceps weakness due to arthrogenic muscle inhibition(AMI) has been reported following anterior cruciate ligament (ACL) reconstruction. The effects of exercise on lower extremity function in the presence of quadriceps AMI may result in neuromuscular adaptations. **Objective:** To compare quadriceps neuromuscular function after exercise in patients with ACL reconstructed knees and healthy matched controls. **Design:**Controlled laboratory study. **Setting:** Laboratory. **Patients or Other Participants:** Fifty-two recreationally active persons volun-teered to participate, 26 had a history of unilateral, primary ACL recons-truction at least 6 months prior (age=24.2± 4.9yrs, height =171.0± 11.4cm, mass=71.2±12.6kg, 39.2± 44.7 months since surgery) and26 age and gender matched controls (age=24.3±4.3yrs, height =171.9 ±10.3cm,mass=70.9± 13.2kg). **Interventions:**All participants performed 30 minutes of continuous exercise involving 5 repeated cycles of aerobic and anaerobic exercises. Each cycle consisted of 5 minutes of uphill walking (aerobic) and 1 minute of body weight squatting and step-ups (anaerobic). **Main Outcome Measures:** Normalized knee extension maximal voluntary isometric contraction (MVIC) torque, quadriceps central activation ratio (CAR), soleus H-reflex and V-wave before and after exercise. CAR was measured using the superimposed burst technique (SIB). While participants performed maximal isometric knee extension, an electrical stimulus was triggered causing a transient increase in torque (SIB).CARwas calculated as (MVIC/SIB)*100.H-reflex was

collected at rest while prone, soleus V-wave was collected during a maximal isometric soleus contraction; both were normalized to peak M-response.Four separate independent samples t-tests were used to analyze pre-exercise differences between groups. Repeated measures 2X2 ANOVA was used for statistical analyseswhilepercentage change(90% confidence intervals) were used to compare the within group effect of exercise.**Results:**Prior to exercise, healthy participants had significantly greater knee extension torque (ACL-R= 2.59±0.68Nm/kg; Healthy= 3.35± 0.84Nm/kg, *P*= 0.001), quadriceps CAR (ACL-R= 75.2±13.4%; Healthy= 88.0±7.2%, *P*<0.001), and soleus VM ratio (ACL-R= 11.0±11.2%; Healthy= 19.1±12.6%, *P*= 0.02) than ACL-R participants.There was a significant group x time interaction for knee extension torque ($F_{(1,50)}$= 11.16, *P*= .002), quadriceps CAR ($F_{(1,50)}$= 5.01, *P*= .03), and soleus V:M ratio ($F_{(1,50)}$= 5.331, *P*= .03). The effect of exercise was smaller for the ACL-R group when compared to matched controls for knee extension torque [ACL-R: %Δ= - 4.2 (-8.7,0.3); Healthy: %Δ= -14.2 (-18.2, -10.2)], quadriceps CAR [ACL-R:%Δ=-5.1 (-8.0.-2.1); Healthy: %Δ = -10.0 (-13.3,-6.7)], and soleus VM ratio [ACL -R: %Δ= 37.6 (2.1,73.0); Healthy: %Δ= -24.9 (-38.6,-11.3)]. **Conclusions:** Patients with ACL-R experienced a different response to standardized exercise than healthy controls. The declines in quadriceps and soleus volitional muscle function were of lower magnitude compared to healthy matched controls. This response suggests an adaption experienced by patients with quadriceps AMI that may act to maintain lower extremity function during prolonged exercise. This may be due to the presence of quadriceps muscle dysfunction following ACL-R.

Examining Morphological Changes of the Anterior Talofibular Ligament in Health and Previously Sprained Ankles

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Context: Lateral ankle sprains (LAS) are among the most common injuries in sport. The anterior talofibular ligament (ATFL) is most susceptible to damage during a LAS. While it is understood that following a LAS, scar tissue forms within the ligament, little is known about the morphological changes in a ligament injury. **Objective:** To examine if scar tissue formation increases the thickness of the ATFL in those with a history of an ankle sprain. **Design:** Within subject, cross-sectional study. **Setting:** Athletic Training Research Laboratory. **Patients or Other Participants:** Twenty-eight Division-I collegiate athletes (18 females, 10 males, age=18.7±0.9 yrs., height=173.3±11.4 m, mass=71.8±18.6 kg) participated in this study. Seventeen subjects presented with a history of unilateral ankle sprains while 11 subjects had never sprained either ankles. **Interventions:** Each participant reported the number of sprains for each ankle. Measurements for thickness of the ATFL were obtained using musculoskeletal ultrasound. An image of the ATFL can be viewed using musculoskeletal ultrasound while a built-in measuring toll quantifies the thickness of the ligament. Thickness was measured at the midpoint of the ligament between the attachments on the lateral malleolus and talus. Measurements were taken from each ankle. A paired *t*-test ($p \leq 0.05$)was conducted comparing thickness measures of each ankle within the same subject. **Main Outcome Measures:** History of ankle sprain served as the independent variable, while the dependent variable was the thickness of the ATFL of both ankles. **Results:** For the never sprained group, ATFL thickness ranged from 1.1 mm to 2.6 mm. There was no difference in ATFL thickness between the left and right ankles (p=1.00; L: 1.9mm±0.2mm; R: 1.9mm±0.4mm). For the unilateral sprained group, the number of previous ankle sprains ranged from 1 to 3. Thickness of the ATFL of the unilateral sprained group ranged from 1.6 mm to 3.3 mm. There was a significant difference (p=0.003) in ATFL thickness of the never sprained ankles (2.1mm±0.4mm) compared to previously sprained ankles (2.4mm±0.5mm). The previously sprained ankles had a significantly thicker ligament than the ankles that have never been sprained. Additional analysis resulted in no difference in the thickness of the ATFL between the 22 ankles of the never sprained group and the 17 never sprained ankles for the unilateral sprained group. **Conclusions:** Since no difference in ATFL thickness is present prior to injury, it can be concluded that morphological changes occur in the ATFL after injury. Scar tissue formation increases the thickness of the ligament. The presence of scar tissue weakens the ligament by reducing its toleration for high loads. Therefore, in addition to the standard rehabilitation after a LAS, clinicians need to emphasize interventions that lessen scar tissue formation within the ligament as a part of the rehabilitation process.

A Descriptive Analysis of Bone Bruise Presence and Severity Based on Location for Patients with Acute Knee Injury

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Context: Bone bruise lesions (BBL) are commonly documented on MRI following acute knee injuries. It has been hypothesized that alterations to acute knee ligament injury treatment algorithms should be modified for patients with severe BBL. BBL are often not described either in the literature or on MRI reports based on severity. Therefore, before treatment modifications can be considered, a better understanding of the presence, location, and frequency of severe BBL in the presence of acute knee ligament injury is required. **Objective:** Our main objective was to present descriptive statistics of BBL presence and severity

based on location for patients with acute knee ligament injury. **Design:** Cross-sectional. **Setting:** Orthopaedic clinic. **Patients or Other Participants:** Twenty-eight subjects (19 males, 9 females, age: 21.7±9.2years, height:175.1±12.7cm, weight:80.8±22.1kg) participated.. Subjects had an MRI documenting acute knee ligament injury (cruciate or collateral ligaments) and an orthopaedic physician evaluation <4 weeks following injury. A total of 1 PCL, 1 MCL and 26 ACL injuries were included. **Interventions:** Each MRI was reviewed by a musculoskeletal radiologist who was blinded to the subject's clinical presentation. For each subject, the number of BBL were identified and lesion location was documented (medial femoral condyle (MFC), lateral femoral condyle (LFC), medial tibial plateau (MTP), and lateral tibial plateau (LTP)). **Main Outcome Measures:** BBL severity was determined using the Costa-Paz Classification (CPC) system (grade 1, 2, or 3). Frequencies were calculated for BBL severity and presence based on location. Percentages for each grade are presented. **Results:** A total of 60 BBL were identified, with 37% occurring on the LTP, 30% occurring on the LFC, and the remaining 33% occurring on the MFC and MTP. A total of 40 (68%) BBL were grade 2, 12 (20%) were grade 3, and 7 (12%) were grade 1. For grade 1, 43% were located on the LTP, 29% were located on the MFC, 14% were located on the LFC and MTP. For grade 2, 38% were located on the LTP, 33% were located on the MTP, 23% were located on the LFC, and 8% were located on the MFC. For grade 3, 67% were located on the LFC and 33% were located on the LTP. **Conclusions:** Previous documentation of BBL outcomes lacked identification of the severity of lesions. Following acute knee ligament injury, a majority of BBL were grade 2. The most severe BBL (CCP grade 3) were located primarily on the LFC and the LTP, which is also were BBL are most commonly identified on MRI. Based on these findings, future research should determine if BBL location and severity influence patient outcomes in order to determine if changes to current treatment algorithms are necessary.

A 2-Week Joint Mobilization Intervention Improves Self-Reported Function, Range of Motion, and Dynamic Balance in Those with Chronic Ankle Instability

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Context: A single joint mobilization (JM) treatment produced modest gains in dorsiflexion range of motion (DROM)but no improvements in dynamic balance in individuals with chronic ankle instability (CAI). Examining the effects of multiple JMtreatments on DROM and dynamic balanceas well asself-reported function would further elucidate the clinical application of JMin CAI rehabilitation. **Objective:** To examine the effect of a 2-wk talocrural JMintervention on DROM, dynamic balance, and self-reported function in adults with CAI. **Design:** Repeated-measures. **Setting:** Laboratory. **Participants:** Twelve adults (6 Males, 6 Females; age =27.4±4.3 years; height= 175.4 ±9.7cm; mass =78.4±11.0kg) with self-reported chronic ankle instability (CAI) volunteered to participate. Subjects reported a history of at least one ankle sprain, two episodes of ankle "giving way" in the past three months, and Foot and Ankle Ability Measure-Sport (FAAM-S)scores of ≤ 80%. **Interventions:** The JMinter-vention consisted of 6 treatment sessionsover 2 wks in which subjects received 2, 2-min sets of Maitland Grade-II talocrural traction and 4, 2-min sets of Maitland Grade-III anterior-to-posterior talocrural JM. **Main Outcome Measures:** DROM was measured using the weight-bearing lunge test, dynamic balance was assessed with the anterior direction of theStar Excursion Balance Test (SEBT), and self-reported function was documented with the FAAM-S. These assessments were measured 1-wk before the intervention (baseline), prior to the first intervention session (pre-intervention), 24-hrs following the final intervention session (post-intervention), and 1-wk following the intervention (follow-up).Separate one-way ANOVAs examinedchanges in DROM (cm), normalized reach distance on the anterior direction of the SEBT(%), and the FAAM-S(%).The independent variable wastime (baseline, pre-intervention, post-intervention, follow-up). Post-hoc dependent t-tests were calculated in the presence of significant time effects. Alpha was set at $p \leq 0.05$ for all analyses. **Results:** Significant time effects were detected for the FAAM-S (p=0.001), DROM (p <0.001), and anterior reach distance (p<0.001). Post-hoc comparisons determined that there were significant changesfrom baseline topost-intervention measures for the FAAM-S (baseline: 56.3±14.7, post-intervention: 73.7±17.7; p=0.01), DROM (baseline: 10.9±3.7, post-intervention: 12.2±3.7; p<0.001), and anterior reach (baseline: 75.1±5.9, post-intervention: 78.3±5.6; p=0.001),pre-interventionto post-intervention measures for the FAAM-S (pre-intervention: 58.6±11.1; p=0.01), DROM (pre-intervention:10.8±3.9cm; p<0.001), and anterior reach (pre-intervention:76.2±5.8; p=0.001), baseline to follow-up measures for the FAAM-S (follow-up:74.2±18.9; p=0.01), DROM (follow-up:12.3±3.6; p<0.001), and anterior reach (follow-up:78.7±4.9; p=0.001), and from pre-interventionto follow-up measures for the FAAM-S (p=0.01), DROM (p<0.001), and anterior reach (p=0.001). There were no changesbetween baseline and pre-intervention measures or betweem post-intervention and follow-up measures for the FAAM-S, DROM, or anterior reach (all p's>0.05). **Conclusions:** The 2-wk JMintervention which targeted the extensibility of posterior ankle noncontractile structures resulted in significant increases in self-reported function, DROM, and dynamic balancein subjects with CAI. Therefore, addressing local impairments in ankle mechanics enhanced patient-oriented and clinician-oriented measures of function in adults with CAI.

Free Communications, Oral Presentations: Clinical Educators' Influence on Student Development

Wednesday, June 27, 2012, 11:00AM-12:00PM, Room 274; Moderator: Paul Geisler, EdD, ATC

12047DOPE

Instilling Foundational Behaviors of Professional Practice in Undergraduate Athletic Training Students: A Grounded Theory Study

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Context: There is significant lack of research on how educational programs are instilling the behaviors from the *Foundational Behaviors of Professional Practice* in their students. **Objective:** The purpose of this study was to investigate the implementation of the *Foundational Behaviors of Professional Practice* in undergraduate athletic training education program curriculums accredited by the Commission on Accreditation of Athletic Training Education [CAATE]. The researchers specifically intended: to discover which strategies are being utilized by programs in educating and in assessing athletic training students in these behaviors; todescribe the confidence of individuals in their abilities to effectively teach and to effectively assess these behaviors within the curriculum to athletic training students; and to discover if individuals responsible for teaching these behaviorsto athletic training students agree with the current CAATE philosophy of assessment of those behaviors. **Design:** The researchers utilized the qualitative tradition of grounded theory. **Setting:** Institutions that sponsor undergraduate CAATE-accredited programs. **Patients or Other Participants:** The researchers recruited 346 program directors of undergraduate CAATE-accredited programs through electronic communication. It was the goal of the researchers to attain a minimal response rate of 10% in order to satisfy the anticipated threshold of data saturation. This was exceeded with a response rate of 26.3% (N=91).**Data Collection and Analysis:** Data was gathered through an expert-piloted qualitative survey administered via Survey Monkey. Focus groups and individual interviews were utilized as member checking after coding of the data. Individuals for these focus groups and interviews were selected from a convenience sample of research participants who indicated interest at the end of the initial survey. Data was coded in the tradition of Corbin and Strauss (2008), encompassing microanalysis (open and axial coding). Integration of the coded data (selective coding) was utilized to refine categories and link them to a core category. This lead to the development and refining of the emergent theory. Member checking, reflexivity, and an external auditor were utilized as methods of verification. **Results:** The core category of student mentoring through modeling emerged due to its ability to link the emergent categories of approved clinical instructor, program director, and faculty instructors. The implicit curriculum emerged as playing a greater rolewhen instructors instilled their students with the behaviors than the explicit curriculum. Approved clinical instructors (ACIs)had the greatest influence on student mentoring through modeling. There was high confidence in program director and faculty ability to mentor through modeling and variable confidence in ACIs ability to mentor through modeling. **Conclusions:** Embedded in this study is the generated grounded theory that student mentoring through modeling by approved clinical instructors (ACIs) is most critical for instilling students with the behaviors that comprise the common values of the athletic training profession.

Clinical Preceptors' Perspectives on Clinical Education in Post-Professional Athletic Training Education Programs

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Context: Clinical education (CE) in post-professional athletic training education is an important aspect to advance clinical knowledge and skills of graduate students. However, little research has been done to assess the factors involved in progressing graduate students as clinicians. Exploring the perspectives of clinical preceptors (CP) will help to understand what is essential to post-professional CE. **Objective:** To qualitatively investigate themes relating to the perspectives and experiences of CPs regarding CE within post-professional athletic training education programs (PPATEP). **Design:** Consensual qualitative research was used as the main approach to explore CPs' experiences regarding CE. An emergent design was applied to the semi-structured interview protocol to allow for flexibility in accordance with emerging results. Randomized and criterion sampling were utilized to solicit participants for the study. Each participant had to be currently assigned as a CP to at least one PPATEP student and be employed in their current setting for at least 3 years. **Setting:** Individual phone interviews. **Patients or Other Participants:** Eleven collegiate CPs (7 males, 4 females; age=38±7.3 years; years of athletic training experience =15±6.6 years) were interviewed. These participants represented eleven of the sixteen PPATEPs. **Data Collection and Analysis:** Interview transcripts were coded for themes regarding CE at the post-professional level. Themes were established based on a consensus process by a 3-person

research team. Each research team member independently coded the data and created a comprehensive codebook. The research team then met as a group to discuss and formulate a consensus codebook that appropriately represented the data. To increase the trustworthiness of the data, triangulation occurred through using multiple randomized participants, an auditor, and member checking. **Results:** Four themes emerged from this investigation: importance of CE, CP responsibilities, CP qualities, and barriers to CE. CPs expressed that CE was important for enhancing clinical skills beyond the entry-level as well as providing opportunities to become more comfortable making daily clinical decisions regarding patient care. CPs also conveyed that the role of an effective preceptor involves several fundamental responsibilities (eg., promoting autonomy, individualizing goals & objective) and qualities (eg., student-centered mentoring, experience, interpersonal skills). Finally, CPs identified several challenges (eg., multiple demands, CPs' lack of time, disconnect between didactic-clinical collaboration) that impose CE at the post-professional level. **Conclusions:** To foster an environment where a graduate student can effectively develop and build on their entry-level clinical skills, preceptors should create an effective learning environment that provides a balance of autonomy and supervision. Preceptors should also demonstrate attributes of a clinician, educator, and communicator to be an effective mentor to a graduate student. Future research should investigate PPATEP students' perspectives to identify aspects of CE that should be emphasized and integrated to enhance CE at the post-professional level.

Evaluating Culminating Clinical Education Experiences of Senior Athletic Training Students

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Context: Previous research has investigated the socialization process of Athletic Training Students (ATSs) during clinical educationand the causes of frustration which develop during those clinical education experiences.ATSs identify Approved Clinical Instructors (ACIs) as mentors and qualities that allow ACIs to be effective mentors have also been determined. However, the perceptions of ATSs regarding their clinical education experiences are not fully understood. It is important to investigate ATS perceptions to allow athletic training educators to provide clinical education experiences that will maximize learning.**Objective:** To determine the perceptions of senior ATSs regarding their culminating clinical education experiences. We were particularly interested in gaining an understanding of senior ATSs as they prepare for professional practice.**Design:** We used qualitative methods to gain rich descriptions of senior ATSs' perceptions of their final clinical education experience. **Setting:**Commission on Accreditation of Athletic Training Education (CAATE) accredited entry-level Athletic Training Education Program (ATEP). **Patients or Other Participants:**Eighteen (13 female, 5 male; age=21.68±.89) ATSs enrolled in their final year of coursework who were completing their culminating clinical education experience volunteered to participate. Participants came from one CAATE accredited ATEP in the mid-Atlantic region.**Data Collection and Analysis:** We asked seniors to evaluate their culminating clinical education experience by completing an open-ended questionnaire. Specifically, we asked the participants to explain how they learned the most from their ACI, to describe a situation where their ACI taught them a valuable skill or lesson, and to give examples of how their ACI was a positive or negative role model and/or mentor.We analyzed the data using Atlas.ti (version 6.6.15, Atlas.ti GmbH, Berlin,Germany)following the principles ofa grounded theory approach. We negotiated over the coding scheme until we reached agreement, performed a peer debrief, and conducted member checks to ensure trustworthiness of the results. **Results:**Three major themes emerged from the data explaining why our participants had overwhelmingly positive culminating clinical education experiences. ATSsenjoy interacting with clinical instructors who act as *appropriate professional role models.* This theme emerged in several different capacities: preserving appropriate professional rapport, demonstrating competence and clinical skills, and through effective communication. Our participants also found value in being able to develop their clinical skills with *appropriate situational supervision.* Finally, ATSs appreciate when ACIs teach them new information by stimulating their *critical thinking skills.* **Conclusions:**To help provide a positive learning environment for senior ATSs, athletic training administrators should select ACIs who can successfully model professional responsibilities, presentATSs with authentic learning experiences, andpromote higher-level thinking. We believe providing ATSs with exposure to ACIs who can meet these criteria may alter persistence decisions and should be a goal of clinical experiences for all ATSs.

Approved Clinical Instructors Influence on Athletic Training Students' Development of Passion for the Field of Athletic Training

Dodge TM, Mazerolle SM: Springfield College, Springfield, MA; University of Connecticut, Storrs, CT

Context: The Athletic training student (ATS) who ispassionate and excited about the field of athletic training islikely to persist to graduation. Approved clinical instructors (ACIs) are capable of exerting significant influence on an ATS, however, very little is known about the methods ACIs utilize to help the ATS develop this passion. **Objective:** Investigate the modeling behaviors of ACIs with attention to their representation of the realistic aspects of working in the field of athletic training. **Design:** An investigativequalitative study utilizing one-on-one interviewing. **Setting:** Athletic Training Education Programs. **Patients or Other Participants:** Seventeen ACIs (3 males, 14 females)volunteered for this study. The participants had an average of 6 ±1.5 years of experience as an ACI, and were engaged in clinical education an average of 20±3 hours each week. Seven of the ACIs worked at the NCAA Division 1 level while 6 worked at the NCAA Division 3 level. The remaining 4 worked at the high school level. **Data Collection and Analysis:** Two researchers completed one-on-one, in-person interviews following a semi-structured format with all ACIs. Interviews were transcribed verbatim and shared with participants prior to analysis. Data were analyzed with a grounded theory approach consisting of open, axial and selective coding. Multiple analyst triangulation and member checks were included as steps to establish data credibility. **Results:** *Mentoring* was characterized by modeling passion for athletic training, accurate representation of professional practice, strong ACI/student communication, and providing students with hands-on experience. Many participants also indicated that *two-way learning* was the most positive attribute associated with being an ACI. However, a common challenge was *role strain* created by clinical teaching and health care responsibilities. Most ACIs indicated that their *passion* for athletic training stemmed from a desire to help others and the dynamic nature of the field, but also indicated that the low pay scale and issues with irregular hours made it difficult at times to model passion for the profession. **Conclusions:** ACIs mentor their students by displaying passion for the field of athletic training and providing them with realistic learning experiences that are aimed at accurately representing the profession. Athletic training students are urged to challenge their ACIs in ways that result in learning opportunities for both parties. The dynamic nature of athletic training appears to be an attractor to the profession, but it is a responsibility of the ACI to help the ATS to develop an appreciation for that dynamic nature if they are to persist to graduation and eventual professional practice. Future research should be aimed examining the mentoring practices of expert ACIs with a history of assisting their students to develop passion and excitement for athletic training.

Educators EBF

Wednesday, June 27, 2012,12:15PM-1:15PM, Room 274; Moderator: Leamor Kahanov, EdD, ATC

Medial Knee Pain in a Collegiate Wrestler

Donovan L, Grindstaff TL, Carson E: University of Virginia, Charlottesville,VA; Creighton University, Omaha, NE

Background: A 20 year-old male wrestler presented with mild left knee pain that started 2 hourspost-practice, while at the national tournament. Past medical history included a left grade II MCL sprain 8 months prior and a left medial meniscus repair 2 years prior. The athlete did not recall aspecific mechanism of injury, but described his knee being subjected to repetitive valgus forces during drills. There was no edema, ecchymosis, broken skin,or deformity of the knee. Mild tenderness (3/10) was noted over the MCL and medial joint line. Range of motion was within normal limits and pain free except for full passive knee flexion. All knee special tests were negative except the valgus stress test and McMurray's test were positive for pain. **Differential Diagnosis:** MCL sprain, medial meniscus injury. **Treatment:** The athlete was referred to the on-site physician whodiagnosed the injury as a mild MCL sprain. The next day, he competed in two matches, which did not exacerbate his symptoms. Byday4 the pain increased to (5/10) and a small knee effusion developed. All vital signs were normal. The athlete was further examined by an on-site physician who diagnosed the injury as a medial meniscus tear. The athlete was placed in a knee brace and given crutches for ambulation. By the evening, the pain increased substantially (10/10), a large knee joint effusion developed, and erythema formed over the medial knee. The athlete was referred to an on-site physician, who aspirated his left knee and referred him to a localhospital emergency department. Based on the evolving presentation, the differential diagnosis changed to staphylococcus infection, cellulitis, gonococcal arthritis, or herpetic arthritis. While in the hospital vital signs remained normal, white blood cell count was reported normal, andthe synovial fluid was cultured. The athlete received IV morphine and Toradol to control the pain and was prescribed Percocet (2 tablets PRN every 4 hours) and indomethacin (25 mg tid). On day 5, the athlete traveled to hishome university and arrived early morning on Day 6. Upon arrival, he was taken to the emergency department, where his knee was re-aspirated andfluidcultured. All vital signs remained normal; however, the erythema had spread proximally. Based on clinical presentation, the attending orthopedic surgeon recommended arthroscopic debridement and irrigation. During the surgery,9 liters of normal saline was used to irrigate the joint, and a hemovac was placed in the joint. After surgery, the athlete was placed on IV chephazolin. On day 8, the culture began to growstaphylococcus aureus bacteria, but the species was not yet identified. Therefore, the antibiotic was changed to Vancomycin. Two days later (day 10), the infection wasidentified as methicillin susceptible staphylococcus aureus (MSSA). On day 10, the athletehad a central catheter inserted (PICC line) in the right brachial vein that extended to the distal superior vena cava, which was used to administer chephazolin for 6 weeks.The athlete was discharged from the hospital on day 10. The athlete was able to return to fullparticipation after the PICC line was removed. **Uniqueness:** Most joint infections have a mechanism of whichbacteria enters through the joint capsule. In this case, there was no known disruption of the skin for bacteria to enter the joint and the original clinical examination presented as a mild MCL sprain. **Conclusions:** Infections may initially present as a musculoskeletal injury making it important for athletic trainers to serially monitor symptoms. In this case, the rapid increase in pain and effusion was atypical for a musculoskeletal injury.

Bilateral Forearm Compartment Syndrome in a Collegiate Rower

Thomson KB, Carson E, Chhabra AB: University of Virginia, Charlottesville, VA

Background: An 18-year old female collegiate rower presented with initial complaints of swelling, tightness and cramping in her left forearm with high intensity rowing, but symptoms resolve within several minutes after practice. The severity of symptoms increased with higher intensity training on the water and on the rowing ergometer. The consistency of the symptoms gradually increased over the next two weeks including slight numbness and tingling in the hand and fingers. Upon examination, point tenderness in both flexor and extensor masses, mild loss of strength compared bilaterally, and slight limitation with wrist flexion and extension motion were noted. Neurological symptoms were not reproducible upon examination. Approximately one month after initial symptoms occurred, the athlete reported having similar symptoms in her right forearm. No previous history of injury to either upper extremity was noted. **Differential Diagnosis**: Muscle strain, delayed onset muscle soreness, blood clot, compartment syndrome. **Treatment**: Initial treatment of symptoms included ice and premodulated electrical stimulation, ultrasound, and deep tissue massage (Graston technique). Compression wraps and sleeves would temporary diminish symptoms during activity and partially decrease symptoms after activity. After two weeks of treatment with no dramatic decrease of symptoms, the athlete was referred for evaluation by an orthopedic surgeon. Radiographs and MRI were performed to rule out any bony or soft tissue injury. EMG testing was performed to rule out any neurological injury due to numbness and tingling in the left hand. These tests were also performed on the right arm subsequent to symptoms

appearing in the contralateral arm. All tests were normal. Compartment testing was then performed bilaterally. Pre-exercise compartment values were elevated in the following compartments: bilateral superficial volar, right deep volar, right compartment with Wad of Henry (brachioradialis, extensor carpi radialis brevis, and extensor carpi radialis longus). The athlete was then placed on an ergometer and asked to perform a 2,000-meter test at maximal effort. Testing was stopped once peak symptoms were reproduced. Post-exercise compartment values were immediately evaluated. Values were elevated in the following compartments: bilateral superficial volar, bilateral deep volar, and right compartment with Wad of Henry. Final diagnosis was bilateral chronic exertional compartment syndrome (CECS). The athlete was referred to a hand surgeon. Since she had not responded to conservative treatment and wanted to continue to row, surgical options were discussed. The athlete decided to have surgery to release multiple volar and dorsal compartments bilaterally. She began a home exercise program consisting of light range of motion and strengthening exercises two weeks post-op while at home for winter break. She was able to start a gradual return to ergometer and rowing activity after six weeks, was back to full activity within 10 weeks, and required occasional treatment for forearm tightness caused by scar tissue and soreness throughout the spring season. **Uniqueness**: CECS is rarely seen in the upper extremities, especially in athletes. A PubMed search for "chronic exertional compartment syndrome" and "forearm" resulted in only 19 articles, none of which referenced rowing. The lack of previous literature illustrates the uniqueness of such a case in the sport. Also, the athlete's initial symptoms were unilateral and only became bilateral after approximately a month. **Conclusions**: While rare, CECS should be considered when evaluating rowers complaining of chronic forearm pain and tightness. Athletes should be referred for testing to confirm the diagnosis prior to surgical intervention. Surgical intervention may be a consideration if all conservative measures have failed. Rowing technique should also be evaluated as a potential cause of increased grip force placed on the handle by the athlete.

Atypical Tibial Stress Fracture In A Male Collegiate Track and Field Thrower

Keeler JP, Culton AP, Games KE, Sefton JM: Auburn University, Auburn, AL; United States Naval Academy, Annapolis, MD

Background: A 21 year-old junior male track and field javelin thrower reported to the athletic training room in April 2010complaining of pain in his anterior lower right leg.The athlete reported symptoms of muscle soreness and tightness in the anterior musculature of the lower leg that had begun the previous week, which had escalated to "unbearable".The athlete reported no previous history of injury toeither side of the lower leg, knee or ankle. Upon evaluation, the athlete was diagnosed and treated for medial tibial stress syndrome.After two weeks of flexibility, strengthening, ice massage and non-impact workouts, the pain had not subsided and athlete was referred to the medical facility on campus for radiographs. **Differential Diagnosis:** Medial tibial stress syndrome, Osteoid Osteoma, Cortical Fibrous Defect. **Treatment:** The radiographs revealed a large, darkened, hole, but the cause was inconclusive. The athlete was placed in a walking boot and referred for further imaging. A Magnetic resonance imaging (MRI) was completed and revealed alarge oblong dark space that was interpreted as a benign tumor or Osteoid Osteoma. The athlete was instructed to cease activity. Following the cessation of activity, the athlete then underwent right shoulder surgery, unrelated to thelower legpain.Three months following the surgery, the athlete reported thatthe pain had returned to his lower right leg during rehabilitation exercises. The athlete was scheduled for a follow-up appointment.Radiographs revealed the area had decreased in size and the diagnosis of stress fracture was made, as the physician felt that an Osteoid Osteomawould not have begun to resolve on its own that quickly.A bone scan completed in early October confirmed stress fracture diagnosis and revealed similar asymptomatic "hot spots" in his other leg. The athlete underwent surgery in late October. The size of the affected area was so large that an intramedullary rod was placed vertically down the length of the tibia to encourage union since it had not resolved in the three months of conservative treatment.**Uniqueness:** Tibial stress fractures more commonly present in distance runners rather than throwers participating in track and field. Additionally, the fracture was in athlete's trail leg, not the more common plant leg, which is subjected to more stress and an additional shearing force. In this case, the athlete's stress fracture was difficult to diagnose because imaging implied an Osteoid Osteoma or Cortical Fibrous Defect, even though symptoms were more consistent with a stress fracture.**Conclusion:** While a stress fracture is a common injury in track and field athletes, its presentation, in this case, was atypical. Characteristically, pain associated with an Osteoid Osteoma is significantly reduced with the use of NSAID's and the pain will worsen at night. These are two symptoms that can be used to distinguish these pathologies. A Cortical Fibrous defect has no symptoms until there is a pathologic fracture and while it is more commonly seen in the long bones, it generally originates at the insertion site of a tendon or ligament. In this case, there was no such origin. An Osteoid Osteoma will generally resolve without treatment over the course of about three years and a Cortical Fibrous Defect will require surgery to prevent pathologic fractures.Most stress fractures are usually treated with rest and limited to no activity, however there have been several other cases,similar to this, of nonunion stress fractures that have used intramedullary rods to encourage union.

Arteriovenous Malformation In Leg Of A 17-Year Old Cross Country Runner: A Case Report

Mayer JM, Brucker JB: University of Northern Iowa, Cedar Falls, IA

Background: A17-year old male high school cross-country athlete reporting generalized shin pain during and after running for the past few days. No bruising, swelling or obvious deformity was present. All neurological, manual muscle and range of motion testswere within normal limits. Bump test was positive, compression test and tuning fork were negative. After 2 weeks of conservative treatment between competitive seasons, symptoms returned immediately. **Differential Diagnosis**: Medial tibial stress syndrome, exercise induced deep posterior compartment syndrome, tibial stress fracture, deep vein thrombosis (DVT) and Arterioveinous Malformation (AVM). **Treatment**: Immediate return of symptoms indicated that medial tibial stress syndrome was unlikely. Additionally, deep posterior compartment syndrome was ruled out because no neurological, circulatory, or muscular weaknesses were present. Thus, tibial stress fracture was considered, so physician referral followed. X-rayswere performed and no fracture was reported. Athlete was told by the physician to go ahead and run. Athlete would attempt to run and once moderate intensity was reached the athlete would report pain, throbbing/pulsating and a slight bruising that was localized to the superior medial aspect of the shin that would subside within 2 hours following activity. Athlete was retold to maintain exercise intensity within a level that did not induce pain. During the 4thweek after the initial visit the athlete reported to the athletic training room immediately following a bout of exercisewhere an increase in temperature was palpable and an observable "black and blue" discoloration about 3 inches in diameter in the proximal medial shin was present suggesting the possibility of DVT or AVM. A vascular surgeon performed two Doppler investigationslooking for a DVT, one without and one with the bruising present. Neither investigation revealed pathology. Still suspecting an Arteriovenous pathology an MRI was performed. A 6.6 cm X 8.8 cmX 2.5 cm tuft of serpiginous subcutaneous vessels was found indicating an angiodysplasia- venous dysplasia. The athlete was then referred to an interventional radiologist to help determine the possibility of Embolization. The radiologist determined the mass of vessels was providing blood to surrounding tissues; therefore, Embolization was not an option. A plastic surgeon was then consulted.To have enough skin to close the wound after excision two tissue expanders were implanted. After approximately 5 months, 10 months after initial visit, the skin was stretched enough to close the area following tissue excision. Final inspection of the excised tissue revealed two AVM masses, one in the skin and subcutaneous tissue and one in themuscular arteries and veins. **Uniqueness**: In an otherwise healthy active 17-year old two AVMs werefound at different depths. These two extracranial AVMs were caught early before obvious deformity or life threatening symptoms were present. Sclerotherapy or Embolization were not an option because the malformations was providing blood flow to skin and muscle and would result in necrosis. **Conclusion**: It is possible for an AVM to present in young healthy athletes as a chronic overuse injury. In order to achieve early detection it is important for medical professionals to be aware of and to consider an AVM in their differential diagnosis. The most reliable diagnostic tool for detecting an AVM is MRI or CT. It is important for patients with suspected AVM's to be closely monitored. Treatment can be very intrusive and lengthy.

The Clinical Outcomes Research Education for Athletic Trainers (CORE-AT) Project: Training Clinical Researchers for Evidence-Based Practice

Snyder AR, Bay RC, Parsons JT, Sauers EL, Valovich McLeod TC: A.T. Still University, Mesa, AZ

Context: Evaluating the outcomes of athletic training services and employing evidence-based practice (EBP) in our profession are paramount and have been incorporated into the 5th edition of the Athletic Training Education Competencies. However, few athletic trainers are educated and trained to conduct clinical outcomes research to support EBP, which serves as a major barrier to future research efforts and advancement of the profession. **Objective:** To 1) educate and train post-professional athletic training students in clinical outcomes assessment (COA) and EBP, 2) integrate electronic medical record (EMR) technology into clinical practice for collecting patient-oriented healthcare outcomes, and 3) disseminate COA and EBP information to the athletic training profession. **Design:** Three-year (2008-2010) educational project. **Setting:** Accredited Post-Professional Athletic Training Education Program (PP-ATEP) and athletic training clinics. **Patients or Other Participants:** Three years of PP-ATEP students (n=25; female=52%) and clinician members of the Athletic Training Practice Based Research Network (AT-PBRN). **Interventions:** PP-ATEP students were enrolled in a 5-course COA and EBP curriculum cognate that included clinical outcomes research, EBP, healthcare outcomes, healthcare information and technology, and patient-centered healthcare courses. Technology was integrated through the development of a custom web-based electronic medical record (EMR) which contains generic and specific patient-rated outcome measures (PROMs). Efforts to disseminate COA and EBP content to the athletic training membership were made through creation of a website (coreat.org). **Main Outcome Measures:** The primary educational outcome was the aggregated COA and EPB course cognate grade point average (GPA). Frequency counts regarding total patient encounters and the number of generated PROMs describes the integration of COA into patient care. Total and average number of unique website visitors, total number of website visits, and page views describe dissemination effort. **Results:** The GPA for the course cognate was 3.71, with all but 1 student completing the entire cognate. Using the CORE-AT EMR, athletic trainers entered over 2,100 injuries and athletes generated over 1,700 PROMs. From the website launch (June 2009), the coreat.org website received 11,544 unique visitors, 20,084 visits, and 30,458 page views, producing averages of 398, 693, and 1,050 each month, respectively. **Conclusions:** Successful education and training of PP-ATEP students was accomplished through the purposeful design of a curricular cognate that blends didactic and clinical education and utilizes technology to assist with concept integration of essential elements of health professions education, as described by the Institute of Medicine and PEW Health Commission. COA and EBP information is being successfully disseminated to the broader athletic training community through the CORE-AT website. Funded by a project grant from the National Athletic Trainers' Association Research and Education Foundation.

A Descriptive Analysis of the Athletic Training Practice-Based Research Network

Valovich McLeod TC, Lam KC, Bay RC, Sauers EL, Snyder AR: A.T. Still University, Mesa, AZ

Context: Analysis of healthcare service models requires the collection and evaluation of basic practice characterization data. Practice-based research networks (PBRNs) provide a framework for gathering data that are useful in characterizing clinical practice. **Objective:** To describe preliminary practice characterization data from the Athletic Training Practice-Based Research Network (AT-PBRN). **Design:** Descriptive study. **Setting:** Secondary school athletic training clinics within the AT-PBRN. **Patients or Other Participants:** Clinicians participating in the AT-PBRN and the patients whom they evaluated and treated. **Interventions:** A web-based survey was used to obtain data on clinical practice site (CPS) and clinician characteristics, while a web-based electronic medical record (CORE-AT EMR) was used to obtain patient and practice characteristics via de-identified data between September 1, 2009-April 1, 2011. **Main Outcome Measures:** Descriptive data regarding CPS and clinician characteristics are reported as percentages and frequencies. Descriptive analysis of patient encounters and practice characteristics data was performed, with the type of injuries at initial evaluation and the type of procedures received at initial evaluation, daily treatment, and daily sign-in reported as percentages and frequencies. **Results:** The AT-PBRN consisted of 23 distinct CPSs across 7 states. Most CPSs were associated with a regional coordinator (athletic training academic program=13, clinic center=2, hospital center=5) and the majority were classified as public or public charter secondary schools (82.6%, n=19). A total of 23 clinicians

participated in the AT-PBRN (males=7, females=16, age= 27.3 ±7.0), with 78.3% (n=18) and 21.7% (n=5) holding a Bachelor's and Master's degree, respectively. The majority of clinicians had been certified for less than 2 years (56.5%, n=13), while 21.7% (n=5) had been certified for 3-5 years, 13.0% (n=3) for 6-10 years, and 8.6% (n=2) for 10+ years. The AT-PBRN documented 2523 patients who were treated across 3140 encounters. Patients had a mean age of 15.9±1.3 years and were fairly evenly distributed across all grade levels. Males (59.4%, n=1500) represented a larger percentage of total patients than females (40.5%, n=1023). Most patients sought care for a current injury (61.3%), followed by preventative services (24.0%) and new injuries (14.7%). The most common diagnoses included ankle sprain/strain (17.9%), hip sprain/strain (12.5%), concussion (12.0%), contusion (10.0%), and knee pain (2.5%). The most frequent procedures were AT evaluation (53.9%), hot/cold pack application (26.0%), taping/strapping (10.3%), and therapeutic exercise (5.7%). The median number of treatments per injury was 3 (IQR=2, 4; range 2-19). **Conclusions:** These preliminary findings describe services provided by clinicians within the AT-PBRN and demonstrate the utility of the PBRN model for obtaining clinical practice data. The AT-PBRN provides a clinical research infrastructure that can be used to measure clinical outcomes, determine optimal treatments through comparative effectiveness studies, define athletic training practice characteristics, and estimate the costs associated with the care provided by athletic trainers. Partially funded by a project grant from the National Athletic Trainers' Association Research and Education Foundation.

Approved Clinical Instructors' Barriers and Accessibility to Evidence For Clinical Decision Making

Hankemeier DA, Welch CE, Newton EJ, Walter JM, Van Lunen BL: Ball State University, Muncie, IN; Old Dominion University, Norfolk, VA

Context: Approved Clinical Instructors (ACIs) are asked to provide instruction and guidance for students in regards to utilizing evidence to guide clinical decision making (CDM). Understanding the barriers to and accessibility of evidence to support CDM will be necessary in continuing to move forward in evidence-based practice (EBP) implementation. **Objective**: To assess ACIs perceived barriers and accessibility to evidence related to CDM. **Design:** Cross-Sectional. **Setting**: Web-based survey conducted spring 2010. **Patients or Other Participants:** ACIs from CAATE accredited programs (n=266; 11.3% response rate; 32.6+8.3 years old; 138 males, 128 females) were selected from a convenience sample. **Interventions**: Program directors of undergraduate athletic training education programs were asked to distribute an e-mail containing a link to complete the online *Evidence Based Concept Assessment* (EBCA) and demographic questionnaire to all ACIs associated with their program. The EBCA consisted of six sections, but only the perceived barriers (16 Likert scale items) and the accessibility (two multi-part questions) sections were assessed in this inquiry. **Main Outcome Measures:** Descriptive statistics were reported as scale values (4.0 pts.) for the perceived barriers and percentages were presented for accessibility. Participants were asked to identify if they have direct access to, and how often they access 10 commonly used resources (e.g., peer-reviewed journals, Cochrane databases, PubMed) for seeking evidence. Additionally, participants were asked to rate their perceptions (4-point Likert scale) of 16 potential barriers (e.g., time, ability to critically appraise literature, collective support among colleagues) for implementing EBP. Barriers were divided into two categories: support and accessibility to resources barriers and barriers associated with their own personal skills and attributes. **Results:** ACIs largely "disagreed" that both support (2.4/4.0±.5) and their own personal skills (2.3/4.0±.5) were barriers encountered in implementing EBP in their clinical practice. On average, ACIs "agreed" that the individual barrier of time (3.2/4.0±.9) prevented them from implementing EBP. ACIs "disagreed" that being able to make independent clinical decisions (2.0/4.0±.8) and the familiarity with internet databases (2.1/4.0±.8) were barriers. In regards to accessibility, ACIs reported having the most direct access to websites and textbooks (98.5%), position statements (95.9%), professional literature (94.0%), and peer-reviewed journal articles (90.2%). Additionally, ACIs reported limited access to clinical prediction rules (79.3%), Cochrane databases (78.6%), and meta-analyses/systematic reviews (51.5%). ACIs also reported that they are unfamiliar or do not utilize Cochrane databases (72.5%), clinical prediction rules (55.6%), or meta-analyses/systematic reviews (20.3%). **Conclusions:** ACIs perceive time as a barrier and are most unfamiliar with or do not utilize resources that contain some of the highest levels of evidence in CDM. Educational interventions need to be developed to promote methods of accessing and implementing quality information to enhance CDM. Future research should address mechanisms ACIs utilize to integrate evidence-based resources into their CDM.

Free Communications, Oral Presentations: Patellofemoral Pain: Etiology and Intervention

Thursday, June 28, 2012, 10:30AM-11:30AM, Room 274; Moderator: Jenny Thorpe, MS, ATC

Functionally Increased Pain Decreases Strength and Influences Mechanics in Patients with Patellofemoral Pain

Bazett-Jones DM, Cobb SC, O'Connor K, Huddleston W, Armstrong B, Earl-Boehm JE: University of Wisconsin-Milwaukee, Milwaukee, WI

Context: Patellofemoral pain (PFP) is a common injury that is described as anterior knee pain during activities of repetitive flexion. Reduced strength has been cited as an etiological factor in PFP, however, recent prospective studies have hypothesized that weakness might be the result of pain and not the cause of it. **Objective:** To investigate the acute effects of increased pain on hip strength and lower extremity mechanics during running. **Design:** Single-session, case series. **Setting:** Neuromechanics Laboratory. **Patients or Other Participants:** Nineteen participants (10 men, 9 women; age=27.3±6.4 years, height=173.3±7.1cm, mass =76.5 ±12.1 kg) diagnosed with PFP longer than 4 weeks volunteered. Participants were required to have pain during 3 of the following: prolonged sitting, running, squatting, stair ambulation. All participants quantified their pain at a level of at least 3/10 using a visual analog scale (VAS). **Interventions:** Pain, strength, and lower extremity running mechanics were assessed before and after a repeated single-leg squats (RSLS) intervention. The participant performed 20 repetitions at a pace of 30/minute and completed sets until they reached the pain level experienced during a prolonged run. Adequate rest was provided between sets to reduce the influence of fatigue. **Main Outcome Measures:** Pain was assessed (VAS) during running before and after the RSLS intervention, and after each RSLS set. Dependent variables also included hip strength (pre-post: abduction, extension, external rotation) and peak knee and hip angles and moments in all planes. Strength was assessed with three, 5-second maximal contractions, normalized to body mass, and then averaged. Running mechanics were recorded with a 3D motion capture system and force plate. Moments were normalized to body mass. Pain was analyzed with a Wilcoxon test. Strength and mechanical variables were analyzed with dependent t-tests. The alpha level was set at $p<0.05$. **Results:** Pain was significantly increased following RSLS during running (Baseline: 3.10±2.0, RSLS: 4.38±2.4, p=0.006). Only hip extension strength decreased signifi-cantly (Baseline: 0.368±0.08, RSLS: 0.326±0.10, p=0.002). Significant decreases in peak hip extension (Baseline: -2.48 ±0.62, RSLS: -2.23± 0.65, p<0.001) and abduction (Baseline: -1.87 ±0.30,RSLS:-1.76± 0.34, p= 0.005) moments occurred following the RSLS protocol. No other strength or mechanical changes occurred (p>0.05). **Conclusions:** Hip function was reduced following the RSLS protocol, which was accompanied by an increase in pain. This study provides preliminary evidence that pain acutely influences hip strength and mechanics, which could explain the lack of prospective evidence for hip strength in PFP. These findings of reduced hip function are consistent with literature of acute injury and experimentally induced knee pain models. Hip weakness may be a result, not a cause of PFP; however further research is necessary. Clinicians should treat hip weakness, specifically in the gluteus maximus muscle, concurrently with methods to reduce pain.

Comparative Strength, Endurance and Pain Responses Among Therapeutic Patellofemoral Taping Techniques

Osorio JA, Vairo GL, Rozea GD, Bosha PJ, Millard RL, Aukerman DF, Sebastianelli WJ: Department of Kinesiology, The Pennsylvania State University, University Park, PA; East Stroudsburg University, East Stroudsburg, PA; Penn State Hershey Orthopaedics – State College, State College, PA

Context: Patellofemoral taping techniques are performed as a therapeutic treatment for patello-femoral dysfunction (PFD). Prior findings suggest such interventions improve quadriceps performance and perceived pain in PFD patients. However, limited evidence exists detailing the effectiveness of contemporary kinesiotape, especially when compared to traditional McConnell. **Objective**: Our primary aim was to investigate immediate effects of different patellofemoral taping techniques on quadriceps performance and perceived pain in PFD patients. It was hypothesized that taping would increase performance and decrease pain compared to no tape. A secondary aim was to compare differences between kinesiotape and McConnell. **Design**: Retrospective cohort. The independent variable was taping technique. **Setting**: Controlled laboratory. **Patients or Other Participants**: Twenty (13 women, 7 men) physically active patients diagnosed with unilateral acute PFD (age = 21.2 ± 2.9 years, height = 1.7.± 0.2 m, mass = 68.1 ± 7.0 kg, Tegner = 6.2 ± 1.3, Kujala = 79.0 ± 9.4). **Interventions**: Patients underwent one bilateral baseline and two unilateral taping testing sessions. Taping consisted of the McConnell medial glide and NUCAP Medical Upper Knee Spider®. Forty-eight hours separated sessions. Ran-

domization was used to prevent order effects. **Main Outcome Measures**: Normalized isokinetic strength and endurance were assessed at 60 °/s and 240 °/s respectively using reliable methods. Pain was measured following isokinetics using a standardized visual analogue scale. One-tail paired t-tests assessed bilateral baseline differences. One-way analyses of variance with Tukey's post hoc test evaluated differences among baseline and taping sessions for the involved leg. $P \leq 0.05$ denoted significance. **Results**: Data met necessary assumptions for statistical analyses. Patients demonstrated significant bilateral baseline differences for strength (involved = 1.9 ± 0.6 Nm/kg; uninvolved = 2.1 ± 0.5 Nm/kg; P = 0.001) and endurance (involved = 35.1 ± 14.3 J/kg; uninvolved = 39.6 ± 13.4 J/kg; P = 0.022). Patients also displayed significant increases in strength (McConnell = 2.2 ± 0.6 Nm/kg, P = 0.002; Spider® = 2.1 ± 0.5 Nm/kg, P = 0.003) and endurance (McConnell = 42.7 ± 14.7 J/kg, P = 0.003; Spider® = 43.5 ± 11.2 J/kg, P = 0.001) when taped compared to baseline. Pain significantly decreased during strength (baseline = 3 ± 2.3 cm; McConnell = 1.9 ± 1.8 cm, P = 0.003; Spider® = 1.7 ± 2.2 cm, P = 0.003) and endurance (baseline = 2.7 ± 2.1 cm; McConnell = 1.6 ± 1.9 cm, P = 0.001; Spider® = 1.2 ± 0.9 cm, P = 0.001) measure-ments when taped. No significant differences existed between taping techniques.**Conclusions**: Patello-femoral taping techniques improve quadriceps performance and perceived pain in unilateral acute PFD patients. No apparent differences exist between the Spider® and McConnell medial glide. Continued research is necessary to definitively determine clinical effectiveness of PFD taping interventions.

A Comparison of Lower Extremity Strength and Static Alignment in Individuals at Risk for Anterior Cruciate Ligament Injury and Individuals at Risk for Patellofemoral Pain Syndrome

Boling MC, Padua DA, Marshall SW, Nguyen A, Cameron KL, Beutler AI: University of North Florida, Jacksonville, FL; University of North Carolina, Chapel Hill, NC; College of Charleston, Charleston, SC; Keller Army Hospital, West Point, NY; Uniformed Services University of the Health Sciences, Bethesda, MD

Context: Those at risk for anterior cruciate ligament (ACL) injury and patellofemoral pain syndrome (PFPS) are theorized to have similar strength deficits and altered static alignments. Research has yet to compare these groups to determine if a single prevention program can be used to decrease the risk of these injuries. **Objective:** To compare lower extremity isometric strength, Q-angle, and navicular drop between individuals at risk for PFPS and individuals at risk for ACL injury. **Design:** Cohort. **Setting:** US Military Academies. **Patients or Other Participants:** The cohort consisted of 5,515 cadets (2,150 females, 3,365males; height= 173.24± 9.20cm, mass= 71.88± 13.05kg) who were freshmen at the time of enrollment in the current investigation. **Interventions:** Each participant underwent a baseline assessment of lower extremity isometric strength, Q-angle and navicular drop. Participants performed two trials for each strength test and all strength data were normalized to body mass. Three trials were recorded for Q-angle and navicular drop. Following baseline data collection, participants who did not report a history of PFPS or ACL injury, were followed prospectively for a maximum of 4 years to determine those diagnosed with PFPS ("at risk PFPS" group) and those who sustained a non-contact or indirect contact ACL injury ("at risk ACL" group). **Main Outcome Measures:** Normalized mean and peak isometric strength of the knee flexors, knee extensors, hip extensors, hip abductors, hip internal rotators, and hip external rotators were averaged across two trials and used for data analysis. Q-angle and navicular drop were averaged across three trials and used for data analysis. Independent t-tests were performed to compare mean and peak isometric strength, Q-angle, and navicular drop between the "at risk PFPS" and "at risk ACL" groups for males and females separately ($\alpha<0.05$). **Results:** Sixty-five cadets (23 females, 42 males) were diagnosed with an ACL injury ("at risk ACL" group) and 133 cadets (71 females, 62 males) were diagnosed with PFPS ("at risk PFPS" group) during the follow-up period. In males, the "at risk PFPS" group was significantly weaker than the "at risk ACL" group for mean (0.35±0.08%BW vs. 0.38±0.08%BW; *P*=0.02) and peak (0.41±0.09%BW vs. 0.46±0.09%BW; *P*=0.01) hip abduction strength. In females, the "at risk ACL" group was significantly weaker than the "at risk PFPS" group for peak hip extensor strength (0.25±0.07%BW vs. 0.29±0.07%BW; *P*=0.03). There were no other significant group differences for males and females (*P*>0.05). **Conclusions:** With the exception of hip abduction strength in males and hip extension strength in females, individuals at risk for ACL injury or the development of PFPS appear to be have similar lower extremity strength and anatomical alignment profiles. Based on these findings, a single injury prevention program may be effective in reducing both the risk of ACL injury and PFPS. Funded by R01-AR050461001 and R03-AR057489-01A1.

Movement Coordination Alterations between the Ankle and Hip during Stair Descent in Patients with Patellofemoral Pain

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Context: Ankle range of motion deficits can be related to various acute and chronic lower extremity pathologies, including patellofemoral

pain (PFP). It has been hypothesized that ankle dorsiflexion and plantar flexion can negatively influence movement at proximal lower extremity joints. However, no study has investigated movement coordination between the ankle, hip and knee during a functional task in PFP patients. **Objective:** To investigate the movement coordination of the ankle relative to the knee and hip during stair descent in patients with PFP and healthy controls. **Design:** Case-control. **Setting:** Research laboratory. **Patients or Other Participants:** Twenty PFP (13F/7M, 21.45± 3.90years, 169.96± 10.47cm,71.30 ± 14.50kg) and twenty healthy participants (13F/7M, 21.35±3.76years, 172.21±9.24cm, 69.68± 9.78kg) volunteered. **Interventions:** Using 3-D motion analysis, joint angles and angular velocity during stance phase of stair descent were obtained to calculate relative phase angles between the ankle and knee, and between the ankle and hip. Mean absolute relative phase (MARP) and deviation phase (DP) were obtained to compare ankle-knee and ankle-hip coordination and variability during stance. Lower values indicate that the inter-joint movement occurs with more restriction and less variability. **Main Outcome Measures:** Dependent variables included MARP and DP of sagittal plane ankle movement relative to knee flexion (DF-KF), to knee valgus (DF-KV), to hip flexion (DF-HF), and to hip abduction (DF-HA) during the stance period. For each dependent variable, separate two-way (Group, Limb) ANOVA's were utilized for statistical analysis. Significance was set *a priori* at $P<0.05$ **Results:** For the ankle-hip coordination, there were statistically significant group differences in DF-HA MARP (Healthy= 81.83±16.94°, PFP= 68.69 ±18.71°, $F_{1,38}=15.073$, $P<0.001$) and DF-HF DP (Healthy =43.99±4.67°, PFP=40.93±5.60°, $F_{1,38}=4.469$, $P= 0.041$). However, DF-HA DP(Healthy =40.31±4.84, PFPF=40.15 ±4.03°, $F_{1,38}= 0.022$, $P=0.883$) and DF-HF MARP (Healthy=54.53±7.29°, PFP= 53.82±8.46°, $F_{1,38}=0.093$, $P=0.762$) yielded no significant group differences. Additionally, no statistically significant group differences were observed for ankle-knee coordination and variability (DF-KV MARP: Healthy= 60.73± 16.94°, PFP =64.34 ±18.00°, $F_{1,38}=0.695$, $P=0.41$; DF-KV DP: Healthy= 38.31±6.92°, PFP= 38.81±5.11°, $F_{1,38}=0.109$, $P=0.743$; DF-KF MARP: Healthy=43.73±5.11°, PFP= 41.03 ±4.98°, $F_{1,38}=3.556$, $P= 0.067$; DF-KF DP:Healthy =35.23±2.94°, PFP= 34.65±2.34°, $F_{1,38}=0.664$, $P=0.420$). There were no significant limb differences. **Con-clusion:** Our results suggest that movement coordination between the ankle and hip may be more restricted in those with PFP. Specifically, PFP patients demonstrated more restricted movement of the ankle in the sagittal plane relative to the hip in the frontal plane, and less variability in movement of the ankle in the sagittal plane relative to the hip in the sagittal plane. Movement coordination deficits between the ankle and hip were more accentuated compared to movement coordination between the ankle and knee. The results may suggest that PFP patients display kinematic deficits at joints adjacent to the patellofemoral and tibiofemoral joint, which may further accentuate the complex nature of this pathology. Clinicians may utilize this information to develop multi-faceted approaches when treating patients with PFP.

Ankle EBF

Thursday, June 28, 2012,5:00PM-6:00PM, Room 274; Moderator: Brian Pietrosimone, PhD, ATC

Effect of Three Ankle Braces on Range of Motion and Functional Performance in Subjects with a History of Ankle Sprains

McDonald J, Chinn L, Donovan L, Hart JM, Hertel J: University of Virginia, Charlottesville, VA

Context:Prophylactic ankle braces are frequently used to prevent ankle sprains during sports participation. Many different types of ankle braces have been marketed such as lace-up braces, semi-rigid braces, and the Seattle Ankle Orthosis (SAO). The SAO has straps that attach a cuff around the lower leg directly to the lateral aspect of the shoe to specifically restrict inversion. Little researchhas been published on the effects that ankle braces have on individuals with a history of previous ankle sprain.**Objective:**To compare the effects of theSAO,a lace-up brace, and a semi-rigid brace to an un-braced control conditionon measures of ankle range of motion (ROM) and functional performance measures in subjects with a history of ankle sprains. **Design**: Crossover.**Setting**:Laboratory. **Participants**: Eleven young adults with a history of previous ankle sprains(6 males, 5 females; age=22.2±1.7 years;height=174.1±12.4cm; weight=75.0±16.2kg; number of previous sprains=3.4±2.3)participated. **Interventions:**Subjects reported to the laboratory for a single testing session. All subjects were fitted and tested in each brace condition (SAO, lace-up, semi-rigid, control) in a randomized order. Subjects wore the same pair of standardized cross-training shoes during all 4 conditions. **Main Outcome Measures**: Dependent variables were inversion and plantar flexion active ROM; dynamic balanceusing the anterior, postero-medial, and posterolateral directions of the star excursion balance test (SEBT); the SEMO agility test; maximumvertical jump;and single-leg triple hoptest for distance.For each dependent variable,a one way ANOVA with repeated measures on brace condition was performed. In the event of a significant main effect, pairwise comparisons were used to identify significant differences between specific conditions. **Results**: Compared to the control condition, all three ankle braces significantly restricted inversion ROM (p=.008; control =36.8±10.0°;lace-up=26.6 ±8.9°;semi-rigid= 25.2±10.2°; SAO= 25.9± 11.8°), however there were no differences between the braces. All three braces also significantly restricted plantar flexionROM (p<.001; control= 50.5±6.8°; lace-up=38.0±4.4°; semi-rigid=40.3±5.1°; SAO=43.4±5.0º). The lace-up brace restricted plantar flexion significantly more than the SAO (p=.018). All three braces significantly reduced SEBT reach distance in the anterior (p=.005; control=65.2±7.7%; lace-up=61.4 ±7.9%; semi-rigid=62.1± 6.6%; SAO=60.1±8.2%) and postero-medial (p=.001; control= 83.2±9.6%; lace-up=77.5±11.9%; semi-rigid= 76.8± 9.5%; SAO=78.3± 10.9%) directions. There were no significant main effect for theSEBT posterolateral reach (p=.062; control= 82.9±9.6%;lace-up=79.0 ±9.4%; semi-rigid= 79.2± 9.1%; SAO=80.0±9.2%), the SEMO agility test (p=.10; control =11.8 ±2.0sec;lace-up=12.2±2.0s;semi-rigid=12.0±1.9s; SAO=12.1±2.3s), vertical jump (p=.09; control = 43.7±13.4cm;lace-up= 39.5± 12.7 cm;semi-rigid =40.6 ±12.9cm; SAO=41.3±12.9cm), and single limb triple hop test(p=.33; control= 457.0±111.8cm;lace-up =445.7 ± 115.8cm; semi-rigid= 450.3± 122.7 cm; SAO=449.2±120.9cm). **Conclusions**: The SAO brace affected ROM restriction and functional performance tasks similarly to the lace-up and semi-rigid braces in subjects with a history of lateral ankle sprain.

How Do Taping Methods Affect Ankle Range of Motion and Functional Performance Measures?

Schulmeyer SJ, Docherty CL, Simon J, Schrader J, Grove CA: Indiana University, Bloomington, IN

Context: Ankle injuries are one of the most common injuries in athletics. Ankle taping methods are commonly used to protect the ankle by restricting range of motion (ROM). It is unclear how limiting range of motion will affect functional performance. **Objective**: To analyze how limiting range of motion using different taping methods affects functional performance measures. **Design:** Crossover design. **Setting:** Laboratory. **Patients or Other Participants:** Thirty-one physically active college aged individuals (age 19.9±1.0 years; height 179.2±9.4 cm; weight 69.7±13.9 kg) with no history of lower leg or ankle injuries in the last 6 months and no lower extremity surgery or fracture in the last year volunteered for the study. **Interventions:** All subjects completed three taping conditions in a counterbalanced order. Taping conditions included: no tape, all white cloth tape, and combination tape using elastic tape for heel locks and figure-8s and white cloth tape for all other components. Prior to and after each tape condition ankle ROM, Agility T-test, and vertical jump tests were performed. An electric ankle goniometer was used to measure ROM in four directions: inversion, eversion, plantar flexion and dorsiflexion. Agility T-test is an agility test consisting of a 9.14m sprint, 4.57m side shuffle to the left, 9.14m side shuffle to the right, 4.57m side shuffle to the left and 9.14m backpedal. Time was measured using an electronic timing system (Brower Timing Systems, Draper, UT) and the fastest of three trials was used for statistical analysis. Vertical jump was measured using a Vertec (Questec Corp., Northridge, CA) and the

maximum of three trials was used for statistical analysis. We performed separate RMANOVAs for agility T-test, vertical jump, and ROM data. Tukey post hoc test was performed on all significant findings. **Main Outcome Measures:** Vertical jump height(cm), agility T-test time(sec) and ankle ROM(°). **Results:** We found a significant difference between the 3 tape conditions for each ROM direction (dorsiflexion: $F_{2,60}$ = 23.17, p=.001, plantarflexion:$F_{2,60}$=59.91, p=.001, inversion:$F_{2,60}$=62.09, p=.001, and eversion:$F_{2,60}$=21.87, p=.001). For each direction, the post-hoc tests showed that the white cloth tape and combination tape conditions restricted more ROM than the no tape condition. However, there were no significant differences between the white tape and combination tape conditions (p>.05). We also found no significant differences among all 3 tape conditions for agility T-test ($F_{2,60}$=4.65,p=.01). For vertical jump, we identified a significant difference between the 3 tape conditions ($F_{2,60}$=19.54, p=.001). White tape (53.4±11.7cm) and combination tape (53.6±11.6cm) conditions resulted in a decrease in performance when compared to the no tape condition (55.7±11.4cm). **Conclusions:** Both taping conditions performed similarly on all tests. These taping methods could be used interchangeably and would result in similar findings related to ROM restriction and functional performance.

Self-Adherent Underwrap Maintains Range of Motion Restriction After Exercise

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Context: The use of athletic tape to decrease ankle range of motion (ROM) is widespread. Various forms of underwrap are often used with taping to allow for protection of the underlying skin. A lack of research exists concerning the most effective form of underwrap that should be used to aid in the restriction of ankle ROM. **Objective:** To evaluate the effects of different underwrap conditions on restricting ankle ROM before and after exercise. **Design:** Cross-sectional study. **Setting:** Research Laboratory **Patients or Other Participants:** Twenty subjects (age 20.8±1.5years; height 175.3±9.2cm; mass 74.4±11.8kg) who exercised a minimum of 3x/week for at least 30 minutes volunteered for this study. Subjects had no history of ankle injury within the previous six months, surgery to the lower extremity, or history of serious medical condition. **Interventions:** All subjects participated in four underwrap conditions: control (no tape or underwrap[NT]), tape applied directly to the skin (TS), tape applied to foam underwrap (TF), and tape applied to self-adherent underwrap (TSA). Subjects came to the laboratory four separate days, one for each condition being tested. Following the underwrap condition application, a closed basket weave taping technique was applied to the ankle. Ankle ROM was measured using an electric ankle goniometer on three occasions. ROM was measured before tape application (pre-tape) and after tape application (post-tape). Subjects then performed 30 minutes of physical activity including: jogging, back-peddling, lateral shuffling, agility ladder drills, and wall jumps. Ankle ROM was measured again after the exercise protocol (post-exc). Two separate RMANOVA were conducted, for each dependent variable. Each analysis had two within subject factors (underwrap condition at four levels: NT, TS, TF, TSA and time at three levels: pre-tape, post-tape post-exc). Tukey post hoc analysis was performed on all significant findings. **Main Outcome Measures:** Ankle ROM was measured in degrees. Data were obtained for two directions: inversion-eversion range and dorsiflexion-plantarflexion range. **Results:** A significant underwrap by time interaction was discovered for inversion-eversion ($F_{6,114}$=33.20, p=.001) and dorsiflexion-plantarflexion ($F_{6,114}$=54.96, p=.001) motions. Post hoc analysis revealed that overall the three different taping conditions significantly restricted inversion-eversion and dorsiflexion-plantarflexion ROM compared to the NT. The TSA condition restricted the most inversion-eversion ROM (46.82° ±2.67°), followed by TS (49.29°± 2.64°), and lastly TF (49.74°±2.60°). The TSA condition also restricted the most dorsiflexion-plantarflexion ROM (47.25°±1.60°). The TF (49.93° ± 1.89°) and TS (48.50°±1.81°) conditions restricted similar amounts of ROM, but neither restricted as much ROM as the TSA condition. For inversion-eversion ROM, the TF and TS conditions had loosened significantly when comparing the post-exc measure to the post-tape measure. However, the TSA condition was able to maintain ROM following exercise. **Conclusions:** Tape to self-adherent underwrap restricts the most range of motion and maintains its restriction after exercise.

Influence of Ankle Flexion Angle on Brace Support of The Ankle-Complex

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Context: No comprehensive analysis concerning the effectiveness of ankle support on ankle-complex ROM across a range of flexion angles has been reported.**Objective:**To evaluate the effect of ankle flexion angle and different types of brace support on ankle-complex dorsi-plantar flexion ROM and inversion-eversion rotation.**Design:**Cross-sectional study.**Setting:** Research laboratory. **Participants:**The dominant ankle of 22 female collegiate athletes (20.7 ± 1.2 years, 70.2 ± 8.7 kg, 173.2 ± 9.0 cm).**Interventions:**Maximal active plantarflexion (PF) and dorsiflexion (DF) ROM and inversion-eversion (I-E) load-displacement curves were collected using a six degrees-of-freedom linkage-instrumented ankle arthrometer. With the subject wearing her own low-top athletic shoe all ankles underwent loading at 10° dorsiflexion

(DF), 0° flexion (neutral) and 15° plantarflexion (PF),which was defined as the zero-load/zero-moment unloaded position.**Main Outcome Measurements:**Maximum achievable angular foot displacement (DF/PF ROM)and total I-E ROM during loading at 4-Nm. Repeated measures ANOVA compared ankle-complex stability among the no brace and braced ankles(soft-shell [Zoom™];lace-up [ASO™];rigid [Active Ankle T2™]) across DF, neutral, and PF angles. Separate single factor ANOVAs were performed to compare differences in ankle DF and PF ROM ratios. The ratio between the ROM with each brace and the ROM without each brace was calculated and reported as a percentage. Significance was set a priori at $P < .05$. **Results:**TheROM ratio showed that the rigid and soft-shell braces provided the greatest amount of dorsiflexion (88 to 90%) and plantar flexion (90 to 95%) ($P > .05$). Whereas wearing the lace-up brace resulted in significantly reducedDF (80.1%) and PF (79.9%) ROMratios ($P < .004$). A significant flexion angle by support condition interaction effect was found for total I-E rotation ($P < 001$). Across each flexion angle, all braces produced a significant reductionin ROM when compared to the no brace trial ($P < .001$). When comparing the braces themselves, the soft-shell and rigid braces significantly decreased I-E ROM versus the lace-up brace at each flexion angle [10° DF: soft-shell (34.7 ± 6.6°) and rigid (31.9 ± 7.6°) brace I-E ROMs were significantly lower than the lace-up brace (44.4 ± 10.9°, $P < .001$)]; [Neutral: soft-shell (37.5 ± 7.8°) and rigid (36.5 ± 8.3°) brace I-E ROMs were significantly lower than the lace-up brace (48.9 ± 12.2°, $P < .001$)]; and [15° PF: soft-shell (40.2 ± 8.9°) and rigid (40.3 ± 10.4°) brace I-E ROMs were significantly lower than the lace-up brace (47.1 ± 12.7°, $P < .001$)]. No significant I-E ROM differences were observed between the soft-shell and rigid braces ($P > .05$).**Conclusions:**The soft-shell and rigid braces provided superior inversion-eversion rotation support across each ankle flexion angle with minimal interference in active plantarflexion/dorsiflexion ROM.

Patellar Taping Improved Pain Scores in Patients with Patellofemoral Pain Syndrome - A Systematic Review

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Context: With society being more active now than in the past, patellofemoral pain syndrome (PFPS) has become more prevalent, accounting for 33% of all knee injuries in females and 18% of all knee injuries in males. PFPS is one of the most common and clinically challenging knee pathologies, found not only in the athletic population, but also in that of the general population. It is believed that this knee pain and discomfort is caused by abnormal biomechanical factors that change the tracking of the patella causing a temporary subluxation of the patella. This momentary subluxation leads to an abnormal distribution of shearing and compressive forces on the patellofemoral joint. A common non-operative intervention used predominantly in the rehabilitation setting is taping. Patellar taping techniques are used to provide support to the patella during movement. However, reports appear inconclusive on its effectiveness. **Objective:** To investigate the efficacy of patellar taping to reduce pain in subjects with PFPS. **Data Sources:** We searched CINHAL, SPORTDiscus, MEDLINE, and PubMed databases through June 2011, using the key words *patella taping* and *pain reduction*, *patellofemoral pain syndrome and taping*, *Kinesio tape for patellofemoral pain syndrome*, and *patellofemoral taping*. **Study Selection:** Criteria for inclusion were studies that exclusively recruited patients diagnosed with PFPS, applied a taping technique as treatment, and utilized an outcome measure specific to pain reduction. **Data Extraction**: Four investigators identified and reviewed six studies with an average PEDro score of 6.75/10. Articles were divided into two categories based on taping technique: 5 using McConnell taping method and 1 using Kinesio taping method. The McConnell taping group was further divided into medial (4), neutral (1) and lateral (2) glide application techniques. Pain level was assessed using a Visual Analogue Scale (VAS). Two different scales were used depending on the type of study. The studies that examined pre-tape pain level versus post-tape pain level used a 0-100 VAS, while the studies that examined tape versus no tape used a 0-10 VAS. **Data Synthesis**: McConnell taping significantly decreased the amount of pain experienced by subjects with PFPS from 34.9% with neutral glide correction to 50% with the medial glide correction when compared to no tape. The data pertaining to Kinesio tape was inconclusive when pre and post pain levels were assessed. **Conclusions:** Data pertaining to the use of McConnell taping shows that there was a significant decrease in pain in subjects with PFPS and should be considered for clinical use. There was only a slight decrease in pain with the application of Kinesio tape, but was not significant enough to conclude its effectiveness. Future research should examine pain reduction effects over time using McConnell taping technique.

Effects of Low-Dye Taping on Measures of Static and Dynamic Balance in Female Pronators

Lougheed CJ, Greenwood LD, Boucher TM: Baylor University, Waco, TX; Texas A&M University, College Station, TX

Context: Low-dye taping is an effective technique used to provide support for the medial longitudinal arch and to reduce symptoms associated with excessive pronation of the foot. While there have been multiple studies performed investigating the effect of Low-dye taping on postural alterations, there have been no investigations on the effects of Low-dye taping on measures of balance which is an integral part of

functional movement. **Objective:** To determine the effect of Low-dye taping on measures of balance. **Design:** Crossover study design. **Setting:** Research laboratory. **Patients or Other Participants:** Nineteen healthy, physically active female volunteers (age 20.8±1.71 years, height 166±5 cm, weight 61.35±8.24 kg) who were pronators. Pronation was determined by having a 10mm or more measurement in the navicular drop test. **Intervention(s):** Navicular drop and measures of balance were assessed in both feet during a no tape condition and a Low-dye tape condition. **Main Outcome Measure(s):** Navicular drop was determined from the height (mm) of the navicular bone in sub-talar neutral and in a relaxed stance. Navicular drop measurements were analyzed with a repeated measures ANOVA and independent t-tests were used post-hoc to determine statistical significant differences between specific navicular drop measures. Measures of balance were collected by the Neurocom Smart Equitest® system. Static balance was calculated by utilizing the Unilateral Stance test(US) and dynamic balance via the Sensory Organization Test(SOT). Dependent variables from the balance tests were analyzed with a paired t-test. **Results:** A significant difference was found in navicular drop measurements between all tape conditions (pre-tape: right foot 13.84±2.06mm, left foot 14.16±2.54mm; post-tape: right 5.11±1.76mm, left 4.95±1.72mm; post-balance: right 7.37±1.83mm, left 8.32±1.70mm). A significant decrease was found between pre-tape and post-tape conditions (right: $t=13.206$, $t_{\alpha/2}=10.626$, $P<.001$).There was also a significant increase after balance testing (right: $t=-5.712$, $t_{\alpha/2}=-3.096$, $P<.001$; left: $t=-7.221$, $t_{\alpha/2}=-4.348$, $P<.001$). The increase seen after balance testing was still significantly lower than pre-tape conditions (right: $t=10.391$, $t_{\alpha/2}=7.783$, $P<.001$, left: $t=9.114$, $t_{\alpha/2}=7.189$, $P<.001$). There were no significant differences found between tape conditions for the US or SOT. **Conclusions:** Low-dye taping significantly alters the posture of the foot as seen by the results of the navicuar drop test. While Low-dye taping was shown to not affect measures of balance as determined by the US and SOT of the Neurocom Smart Equitest®, more research is needed to determine effectiveness of Low-dye taping in concern with exercise, dynamic balance and maintaining foot posture. Low-dye taping should continue to be utilized in the clinical setting when decreases in navicular drop measurement are indicated.

Cystic Macular Edema and Central Retinal Vein Occlusion in a Female Collegiate Lacrosse Player: an Uncommon Case of Blurred Vision

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Background: A 20-year-old, Caucasian, female NCAA Division III lacrosse player (1.68 m, 58.18 k) presented with initial complaints of intermittent blurriness in her right eye that was relieved with light finger tip pressure. She reported that her central vision had been diminishing over a period of 2 weeks as if there was "a film over the right eye". No MOI or pain reported. Patient was a non-smoker,reported occasional consumption of alcohol, no allergies. Medications included Ortho Trycyclin Lo (norgestimate/ethinyl estradiol) for menstrual irregularity. No personal or family history of eye injury or disorders. Upon initial examination, the patient's pupils were equal, reactive to light; no noted discolorations or deformities of the sclera, cornea or iris. Eye movements were unaffected. She demonstrated a significant vision deficit (Left - 20/30; Right - 20/200). The patient was referred to an optometrist for examination on the same day she reported to the AT. **Differential Diagnosis:** Myopia, Retinal detachment/ necrosis, uveitis, macular degeneration/edema, central retinal vein occlusion (CRVO). **Treatment:**Physical exam at the optometrist revealed macular edema, papilitis (degeneration of the optic nerve), and retinal hemorrhage. The patient was referred the same day to a retinal specialist for further workup. Red cap test was positive for diminished optic nerve function. Ocular coherence tomography and fluorescein angiography resulted in a diagnosis of CRVO with cystic macular edema. In order to reduce retinal edema , the patient received 0.05ml intraocular injection of bevacizumab, a vascular endothelial growth factor (VEGF) inhibitor common in the treatment of cancer. To address the inflammation, minimize clotting risk, and likelihood of possible autoimmune involvement, oral medications also included 20mg predisone*qd*, 7.5 mg methotrexate weekly, 75 mg cyclosporine *bid*, 81 mg aspirin*qd*, 20 mg Pepcid AC *qd*, and 1mg folic acid *qd*. Patient was advisednot to participate in athletic competition and to avoid valsalvic pressure. The patient developed candidiasis as a result of corticosteroid use and was treated with 150 mg fluconazole.At week 4, the patient's right eye vision returned to 20/3 and reduced edema, pressure, and hemorrhaging. Analysis of blood samples on follow-up revealed the patient was heterozygous for Factor V Leiden, a genetic mutation associated with increased risk of thrombosis. The patient was instructed to discontinue birth control medications to minimize risk of clotting. Injections of bevacizumabwere to continue at 4 week intervals. The patient was cleared to participate in intercollegiate lacrosse with required eye protection. At week 15 (after missing her treatment at week 12), her vision was again 20/250 with significant macular edema. Following a repeat bevacizumabinjection, the patient's vision and macular edema returned to normal. The patient was counseled to minimize excessive valsalva pressure, continue to monitor vision changes, and continue bevacizumab treatments every 4 weeks. **Uniqueness:** The incidence rate of CRVO is less than 10% in those under 25 and is most often a complication of diabetic retinopathy in the elderly. The incidence rate in the general population is 0.5%. This case is also unique because the patient was diagnosed as being a heterozygous carrier of factor V Leiden increasing her risk of CRVO five to seven fold.Finally, bevacizumab, a VEGF inhibitor,is most often associated with chemotherapy and not a familiar medication to ATs in the treatment of edema.**Conclusions:** Though macular edema and retinal vein occlusions are not usually seen in youth and young adults, they can result in permanent blindness in the affected eye if left untreated. ATs should closely monitor atraumatic vision changes in their patients and refer to an eye care specialist as appropriate.

Medical Clearance and Return to Play Decisions for a Female Division I Volleyball Player with Wolff-Parkinson-White Syndrome

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Background: During the Pre-Participation physical examination process, a 20 year old, female, collegiate volleyball, transfer student-athlete from Australia reported a previous diagnosis of Wolff-Parkinson-White Syndrome (WPWS). This athlete had a catheter ablation procedure at the age of 11, but she continues to have episodes of supraventricular tachycardia while participating in athletic activity and at rest. The university medical staff has been unsuccessful in retrieving her previous medical recordsdue to the date of the procedure and being out-of-country. After an unremarkableElectrocardiogram (ECG), treadmill stress test, and echocardiogram,the athlete was cleared for participation by the Cardiologist. **Differential Diagnosis:** Atrial Fibrillation, Atrial Tachycardia, Sick Sinus Syndrome **Treatment:**This athlete had her first tachycardia episode three weeks after clearance during volleyball practice. She was immediately removed from participation and moved into the athletic training room. She was instructed to lay supine and performa valsalva vagal maneuver, and the tachycardia episode was

successfully broken. This tachycardia episode lasted for 4-5 minutes. The athlete was returned to participation with a heart rate measuring 90 BPM about 10 minutes after the tachycardia episode subsided. This athlete had a re-evaluation with the Cardiologist and was informed that another episode of tachycardia would result in a removal from participation and referral to an Electrophysiologist. This athlete sustained another episode of tachycardia during participation on a road trip five weeks later. The athlete was immediately removed from participation and brought into locker room. The athlete was again instructed to lay supine and perform a valsalva vagal maneuver, and the tachycardia was successfully broken in 45-60 seconds. The athlete was referred for a consultation with an Electrophysiologist one week later. After herinitial evaluation and unremarkable ECG, the Electrophysiologist presented three options for treatment. The athlete could undergo an intracardiac electrophysiology study (EPS) to determine the accessory pathway in her heart's electrical system, take beta blockers to decrease the electrical activity of the cardiac rhythm, or wear a Holter monitor for 4 weeks, in hopes of documenting an episode of tachycardia. The EPS is an invasive procedure that would require time loss during her competitive season and there is a lack of research supporting the effectiveness of the use of beta blockers to decrease cardiac electrical rhythm. As a result, the athlete opted for the use of the Holter monitor.If the athlete has another episode of tachycardia, she is to remove herself from participation and record the heart rhythm. **Uniqueness:**The athlete is an international student and her catheter ablation procedure was performed 9 years ago. As a result, the sports medicine staff has not been able to retrieve the records. Until the records are retrieved and reviewed, the Cardiologist cannot determine which electrical pathway her past catheter ablation procedure was performed on without another EPS. Research has shown that the catheter ablation treatment has a success rate of 85-90%, however, this athlete continues to have issues. Additionally, WPWS is an uncommon cardiac disorder. The incidence of WPWS is between 0.1% and 0.3% of the general population, and is even less common in an athletic population. This is a cardiac condition that must be monitored on a daily basis and needs immediate treatment should an episode oftachycardia occur. **Conclusions:**This is an unusual case and very rare in the athletic population. Even at the risk of having an episode of tachycardia, athletes who have Wolff-Parkinson-White Syndrome can be cleared with proper pre-participation testing and education, supervision while participating,immediate care, and post-episode consultations.

Idiopathic Thrombocytopenic Purpura in a Recreational Runner

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Background: A 23-year-old college student participating as a recreational runner was referred by her athletic trainer to urgent care with complaints of excessive bruising of unknown origin. The patient noticed bruising and red marks on her body increasing over a period of 2-days. Bleeding of the lips and gums began 2 days prior. Patient history indicated no recent illness or stress other than regular class load. In the urgent care, skin demonstrated diffuse petechiae on the calf and hand bilaterally with purpura on the back and shoulders, epistaxis in the nostrils bilaterally, and three bleeding ulcerations on the tongue. The remaining HEENT was unremarkable. Cardiopulmonary, musculoskeletal, neurological, gastrointestinal, and lymphatic systems were all unremarkable. A complete blood count (CBC) indicated a platelet count of 1 K/mL. The remainder of the CBC was within normal limits. PT/PTT were within normal limits. **Differential Diagnosis:** Post-transfusion purpura, Inherited non-immune thrombocytopenia, Aplastic anemia, Type IIB von Willebrand's disease, Malignant lymphoproliferative and myeloproliferative disease, Leukemia, Human immunodeficiency virus (HIV) infection, *H. pylori* infection, Cytomegalovirus (CMV) infection, Hepatitis C infection, lupus erythematosus (SLE), Drug-induced thrombocytopenia, Idiopathic thrombocytopenic purpura (ITP). **Treatment:** The patient was hospitalized for 2 days during treatment. Intravenous immunoglobulin G (IVIG) was initiated. Oral prednisone 80mg daily was also initiated with Protonix 40mg daily to reduce GI irritation. A diagnosis of ITP was confirmed after other blood disorders were ruled out and bone marrow biopsy and aspiration demonstrated hematopoietic cells, fat cells, and connective tissues within normal limits. Platelet count responded well initially to the IVIG but did not respond to the prednisone. A splenectomy was scheduled after the patient did not respond to 2month of prendisone. The patient was provided a third dose of IVIG 3days prior to the surgery. The platelet count increased 2days prior to the splenectomy with the highest platelet count since the onset of treatment (75 K/mL). The splenectomy was canceled, and the patient reached and maintained 150 K/mL. Prednisone was slowly tapered over 3months by 5-10mg per decrease. The patient has experienced no relapse. **Uniqueness:** This patient demonstrated both ITP-A (adult onset) and ITP-C (childhood onset) signs and symptoms where ITP-C typically occurs with a rapid onset and resolves within 6 months and IPT-A is slow onset that is chronic in nature. Standard treatment procedures of corticosteroid and IVIG drug therapy wereinstituted and determined ineffective prematurely in this patient, which may be due to the onset characterized as ITP-A rather than ITP-C. The uniqueness of this case may indicate that practitioners should use both ITP-A and ITP-C diagnostic onset evaluation for young adults in order to successfully diagnose young adults. **Conclusions:** ITP has two differing onsets based on age of inception. ITP-C and ITP-A have identical clinical

features and treatment regimes, yet onset and prognosis differ. Athletic trainers should be awareof these differencesfor continued treatment, monitoring and return to participation criteria in the young adult population. In addition, ITP should be added to the range of general medical clinical knowledge for referral purposes. Treatment for both ITP-C and ITP-A should be similar but cautionary in the decision to conduct a splenectomy, particularly with young adults who may display both ITP-C and ITP-A characteristics resulting in spontaneous remission.

Ear Trauma: A Case Review of a 26-Year-Old Male Arena Football Offensive Lineman with Intra-Tympanic Hemorrhage Secondary to a Concussion

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Background: A 26-year-old arena football offensive lineman participating in "bull in the ring" blocking and tackling drill was positioned in the center of the "ring" when he was blind-sided by an opposing teammate. He sustained a direct helmet-to-helmet blow to the right temporal area of his football helmet. He immediately removed himself from the drill and reported to the athletic trainer for evaluation. Initial sideline evaluation revealed mild headache, mild confusion, dizziness, photophobia, and tinnitus. The athlete reported no tenderness over the head, face, neck, or jaw. Bilateral upper extremity strength and reflexes were normal. No complaints of hearing difficulties. Initial diagnosis of concussion was reaffirmed by team physician evaluation within 12 hours of initial injury. Large post-auricular contusion over the right mastoid process was noted from helmet trauma, and diffuse right intra-tympanic hemorrhage was noted on tympanic membrane examination. No hemorrhage (hemotympanum) or effusion of middle ear. Abnormalities on vestibular testing, accommodation, and convergence testing also noted. **Differential Diagnosis:** (1) Chronic Otitis Media, (2) Barotrauma, (3) Skull Fracture, (4) Hemotympanum, (5) Intra-tympanic hemorrhage. **Treatment:** CT and MRI with attention to the temporal bones showed no fractures or bony abnormalities, ear ossicles intact, no brain pathology or bleeding noted. Abnormal neuropsychological testing compared to baseline c/w concussion. Audiology examination was within normal limits. The findings indicated intra-tympanic hemorrhaging secondary to barotrauma caused by helmet-to-helmet contact; mastoid contusion. The patient suffered with post-concussive syndrome for the entire season, was referred to Neuro-psychology after 3 weeks, underwent vestibular physical therapy for several months, and is now back to work and retired from football. **Uniqueness:** Intra-tympanic hemorrhage is a rare diagnosis most often caused by a basilar skull fracture or barotrauma associated with diving or a blast. To the author's knowledge no such report exits of an Intra-tympanic hemorrhage secondary to a helmet-to-helmet blow. **Conclusions:** The tympanic membrane (TM) is a highly vascular membrane that is very sensitive to variations of atmospheric pressure. Overpressure can enter the external auditory canal, stretching and displacing the TM and causing injury ranging from intra-tympanic hemorrhage in minor cases to total TM perforation in powerful blasts. This concussed football player was never able to return to play due to his concussive symptoms.

Acute Illness in a Male High School Lacrosse Athlete

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Background: Our subject is a 17 year-old male high school lacrosse athlete with a history of postconcussive syndrome. After examination by the athletic trainer, the subject was sent to his family practice physician on September 10, 2011, seven days after onset of unusual and progressive symptoms. Subject's symptoms were initially characterized by nausea, persistent ~104° fever, extreme fatigue, irritability, elevated heart rate (90 bpm), and severe headaches. Chest pain and tightness had developed along with liver tenderness, salmon-colored rash involving trunk and extremities, dry cough, sore throat, strawberry tongue, bright-red rash with sores inside mouth and throat and severely cracked lips. Blood tests indicated significantly elevated white blood cells, for which antibiotics were prescribed to treat what was thought to be a systemic infection. The subject lost 20 pounds in the first two weeks. Joint aches persisted with pronounced neck and shoulder pain. Lymph nodes in the neck were swollen with left side measurably larger. Feet exhibited slight purple discoloration along with peeling of the skin on soles, palms and fingers. Eyes were very red with significant photophobia. Dizziness, nausea, anorexia, and insomnia ensued. Subject's declining condition prompted a second doctor visit and referral to an infectious disease specialist. After examination by the infectious disease specialist and a consultation with a rheumatologist, the subject was hospitalized. **Differential Diagnosis:** Mononucleosis, strep throat, scarlet fever, rheumatic fever, bacterial blood infection, toxic shock syndrome, Kawasaki syndrome, adult-onset Still's disease, periodic fever syndrome, aseptic meningitis, Behcet's disease, genetic autoimmune inflammatory reaction, hepatitis, SLE disease, cytomegalovirus, viral exanthema, antigen-antibody allergic reactions disorder, Reiter's syndrome, HIV. **Treatment:** Seven-days after onset of symptoms, testing was negative for mononucleosis and strep. A tentative diagnosis of a bacterial infection determined and was treated with Azithromycin. After 6 more days, no improvement, hepatitis and HIV testing negative, treatment was initiated for symptoms for what was thought to be Kawasaki syndrome. There are no confirmation tests for Kawasaki

syndrome, an autoimmune inflammatory reaction affecting medium-sized blood vessels. The cause of Kawasaki syndrome has not been determined. However, lack of prompt treatment in other Kawasaki cases (more than 10 days from onset of symptoms) has led to aortic aneurysms. Subject was hospitalized and treated with intravenous immunoglobulin, at a dose of 2g/kg (160g) administered intravenously over a 12-hour period. This immunoglobulin treatment suppressed the immunological reactions causing the inflammatory response to the blood vessels. Four 325 mg. aspirin tablets and one Zantac antacid were also administered every 6-hours in conjunction with the IV immunoglobulin to reduce inflammation and fever. The Zantac antacid was used to protect the stomach lining from the high dose of aspirin. Septra DS and Doxycycline were administered as a precautionary treatment for MRSA–induced Toxic Shock Syndrome. Kawasaki syndrome diagnosis was confirmed when the subject's symptoms significantly resolved several hours after completion of treatment. **Uniqueness:** An extremely small number of patients (fewer than 100) worldwide have been documented with adult Kawasaki syndrome. Adult rehabilitation strategies and techniques are virtually unknown. 15-25% of pediatric cases result in aortic aneurysms, with only 50-75% of those cases resolving themselves. Adults fare better with only 5% resulting in aneurysms. **Conclusions:** Two months following the onset, our subject is slowly working towards a full recovery, now taking 1300 mg/day of aspirin. At this point, headaches persist and sleep patterns are not back to normal. His eyes are still red and light sensitive. His palms, fingers soles are still peeling, however, there are no new lesions. Given the rarity of Kawasaki syndrome in adults, there is limited data to predict a full recovery time frame.

Contagious Skin Infection in a Division I Collegiate Football Team

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Background: Six healthy collegiate football players presented with multiple expanding skin lesions on their extremities over the course of 14 days. The first athlete reported with an erythematous, ovoid blistering group of lesions on the left proximal upper extremity and described a burning sensation and general discomfort over the area. He denied that the lesions were itchy. Despite the initiation of Valtrex(Valocyclovir) by the team physician for a presumed herpetic source, the lesions did not clear and additional smaller circumferentially blistering lesions arose adjacent and on the opposite extremity. A second athlete later presented with two circular-to-ovoid forearm lesions. One of these lesions was rimmed with erythema, had a central pallor, noted to itch more than burn. Topical fluconazole prescribed by the team physician for probable tinea (ringworm) had no benefit and several additional lesions developed in the antecubital fossa. Lesions similar in nature arose on four additional athletes over the next week. They were circular-to-ovoid with erythematous rims surrounding a more central pallor or scabbed core and ranged in size from 0.5cm to 2.5 cm in diameter. These four athletes applied antibiotic ointment and covered the lesions for practice activities as directed by the team physician. Four of the six athletes were offensive lineman frequently in contact with each other during drills. The other two were a linebacker and a tight end. Dermatology was consulted. **Treatment:** A team of three dermatologists evaluated the six student-athletes and upon clinical examination diagnosed bullous impetigo. Each athlete was treated with Cephalexin (Keflex) , one gram twice daily x 14 days, Mupirocin 2% (Bactoban) topical cream to apply three times daily, and Chlorhexadine wash (Hibiclens) wash to shower with twice daily. The football facility (weight and athletic training rooms, locker rooms and showers), was inspected by Certified Athletic Trainers, doctors and facility staff for assurance of proper cleanliness. The importance of proper cleaning of equipment and no sharing of towels, razors, and personal items were re-emphasized to all football athletes. The lesions were to be covered for daily activities and practice until dried, as per recommendations by the team physicians and dermatologists. **Results:** All lesions were improved and no new lesions had developed several days into treatment. All of the lesions were completely dry and the athletes were cleared to compete without wound coverage seven days after treatment was initiated. No new athlete cases were reported. **Uniqueness:** Unlike classic impetigo, a skin infection mostly seen in young children caused most commonly by streptococcus, bullous impetigo is characterized by blistering lesions and is caused by staphylococcus. This infection is contagious and can present in populations where close contact is ubiquitous. Reports of this are documented in the sport of wrestling, but an outbreak amongst collegiate football players is unique. Due to the nature of this skin infection, the initial diagnosis is challenging. This skin condition can mimic other skin infections including herpes and tinea corporis. **Conclusion:** Athletic medicine personnel should be aware that bullous impetigo can be a cause of skin infections in the collegiate football environment, and once diagnosed, is responsive to treatment. Due to the contagious nature of this skin infection, proper diagnosis and immediate treatment are needed to successfully treat the infection as well as to prevent its further spread.

The Sleeper Stretch as an Evaluative Measure – A Preliminary Report

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Context: The sleeper stretch (SS) is a commonly used intervention for patients and athletes with decreased glenohumeral (GH) internal rotation (IR) range of motion (ROM). Recently, investigators have identified the SS is a more reliable objective measure of GH IR ROM when compared to quantifying IR at 90 degrees of abduction. However, many questions exist regarding the use of the SS as an evaluative measure. **Objective**: This study had several objectives: 1) To identify normal SS values in a healthy college age population; 2) To determine if SS values differed between: a) dominant and non-dominant extremities; b) gender and; 3) To determine if sleeper stretch values were related to the ability of a subject to reach their thumb up their back (TUB). We hypothesized that there would be no difference in SS values between sides or gender but that SS values would be related to TUB measures. **Design**: Descriptive. **Setting**: Research laboratory. **Patients or Other Participants**: A convenience sample of 40 healthy, recreationally active college aged students (20 male: age=22.1±2.1 years; weight= 84.1± 14.0kg; height= 181.3±14.8cm; 20 female: age=20.6± 1.2years; weight=62.5±7.6kg; height= 174.0±17.0cm) participated. **Interventions**: First, intra-rater reliability of the dependent measures was established in 10 shoulders. Next, using a standardized protocol, we: 1) measured GH IR ROM in degrees using a digital inclinometer (Pro 360, Baseline®, Fabrication Enterprises, White Plains, NY) three times bilaterally in the SS position and 2) quantified the percentage a subject was able to reach their TUB to the nearest spinous process three times bilaterally with a rigid tape measure mirroring previously published methods. **Main Outcome Measures**: Dependent variables included SS values and TUB measures. We used descriptive statistics to describe 'normal SS' values; paired and non-paired t-tests respectively to determine if SS values differed between extremities and gender and correlation analyses to determine if SS values were related to TUB measures. **Results:** Intra-rater reliability for both SS (ICC [3,k]=0.924) and TUB measures (ICC [3,k]=0.935) were excellent. The grand SS mean was 48.4±12.5°. SS values on the non-dominant side (51.7±10.3°) were greater than those on the dominant side (45.2±13.8°) (P=0.001). No difference between gender was apparent on either the dominant (male=43.2±16.6°; female=47.1±10.3°; P=0.374) or non-dominant (male= 50.2±10.7°; female=53.3±10.0°; P=0.348) side. A fair but statistically significant correlation was evident between SS values and TUB measures on the dominant (r=0.421; P=0.007) but not non-dominant (r=0.252; P=0.116) side. **Conclusions**: SS values are less on the dominant upper extremity and do not differ between healthy male and female college age subjects. SS values are related to a healthy subject's ability to perform a functional IR task (TUB) on the dominant side. These preliminary data provide a baseline reference to which sport specific and injured populations of a similar age group can be compared.

Altered Scapular Muscle Activation in Individuals with Shoulder Pathology Exists During Functional Shoulder Exercises

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Context: Alterations in scapular muscle activation affect stability, often occurring with glenohumeral (GH) pathology. Functional rehabilitation exercises aim to re-establish activation of muscles and force couple relationships for stability through whole-body movements. **Objective:** Determine whether scapular force couple activation ratios and individual muscle activity [upper trapezius (UT), middle trapezius (MT), lower trapezius (LT), and serratus anterior (SA)] differ between functional exercises in GH pathology subjects and healthy controls. **Design**: Cross-sectional. **Patients or Other Participants:** Forty subjects (GH pathology: n=20; age, 23.65 ± 3.25 yrs; height, 170.69 ± 11.55 cm; weight, 74.57 ± 13.13 kg , Healthy control: n=20; age, 24.80 ± 3.59 yrs; height, 172.85 ± 9.01 cm; weight, 72.78 ± 15.65 kg) of convenience were tested. **Interventions:** Participants were screened and placed into GH pathology or healthy control groups. Each participant performed 4 functional exercises [Bow and Arrow (BA), External rotation with scapular squeeze (ERSS), Lawnmower, Robbery] while muscle activity was recorded. The exercise was performed over a 3-second period. An accelerometer was used to synchronize data. **Main Outcome Measures:** Electromyography (EMG, Noraxon USA Inc, Scottsdale, AZ) was used to collect muscle activity from UT, MT, LT, and SA. Integrated EMG (iEMG) was normalized to maximum voluntary isometric contraction. Scapular force couple activation ratios were calculated by dividing normalized iEMG values of the UT by normalized iEMG values of the MT, LT, and SA to generate ratios UT/MT, UT/LT, and UT/SA, respectively. A ratio value greater than 1 corresponded with more UT activity and a value less than 1 represented less UT activity with respect to the MT, LT, and SA. Exercise x group repeated measures analysis of variance (ANOVA) was used to analyze data. **Results**: UT/MT and UT/LT activation ratios were similar during BA and Robbery ($p>.05$); both had greater activation than lawnmower ($p<.05$) and

ERSS ($p<.05$). A trend for higher UT/SA activation ratios in GH pathology subjects was found during Robbery ($p=.047$). An interaction for UT and MT revealed more activation in GH pathology subjects during Robbery ($p=.001$ and .018, respectively). A trend for less LT activity during Lawnmower ($p=.053$) was found in GH pathology subjects. SA had more activity during ERSS than Robbery ($p=.001$) and BA ($p=.007$). **Conclusions**: Findings of increased UT and diminished LT activation align with previous research using pathologic subjects, evidenced by altered scapular force couple activation ratios. Altered muscle activation may compromise scapular stability in GH pathology individuals. Lawnmower and ERSS exercises elicit less UT activation while promoting MT, LT, and SA activity in all three scapular force couples. Funded by the NATA Foundation Masters Grant Program.

Compliance to a Standardized Exercise Protocol Positively Affects Patients with Superior Labral Lesions

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Context: Surgical management and post-operative rehabilitation of Superior Labral Anterior-Posterior (SLAP) lesions has been well established in the literature with generally positive outcomes. Non-operative management of SLAP lesions is under reported in the literature. It is unknown if patient compliance to a standardized physical therapy (PT) intervention has a positive effect on patient outcome, and if so, how compliance to non-operative rehabilitation program affects outcome. **Objective:** To determine if patient compliance has an effect on outcome. We hypothesize that patients who have a positive clinical outcome will be more compliant with a standardized rehabilitation protocol. **Design:** Prospective cohort, quasi-experimental. **Setting:** Outpatient clinic. **Participants:** 33 patients (25 males) at the Lexington Clinic (height=176±9cm; weight=83±18kg; age=40±12yrs) presenting with shoulder pain were enrolled. Patients presenting with at least 3 out of 4 clinical tests or a positive MRI finding were clinically diagnosed to have a SLAP lesion. **Interventions:** Patients were prescribed a standardized rehabilitation protocol and saw a physical therapist of their choosing. Patients were instructed to complete exercises deemed appropriate by their physical therapist, based on the protocol and in accordance with their symptoms, level of function, and treatment goals. The protocol addressed range of motion limitations and progressed patients through 4 levels of exercise: scapular and trunk stabilization; strengthening with a short lever arm; strengthening with a long lever arm; and eccentric/plyometric exercises. Exercise logs and PT notes were collected from patients at the 6 week physician visit. We performed a Chi-square test for compliance and a Mann-Whitney U test for total weeks in PT with significance set $p \leq .05$. **Main Outcome Measures:** Dependent variables included total weeks in PT and compliance to our program. A patient was considered compliant if they performed e"65% of the standardized program as determined by reviewing patient notes and logs. The independent variable is outcome, based on physician recommendation at six weeks; those doing well and were to continue rehabilitation (responders) or those recommended for surgical intervention by physician (non-responders). Physician recommendation for surgery was based on continued symptoms and functional deficits, despite conservative rehabilitation. **Results:** 17 (52%) patients were deemed 'responders' to the protocol, with 16 (48%) non-responders. 12/17 (71%) responders were compliant to our protocol, while only 6/16 (38%) of non-responders were compliant ($p=.056$).Responders were found to be enrolled in supervised PT longer (5±3weeks) than non-responders (3±3 weeks, $p=.047$). **Conclusions:** Conservative intervention of SLAP lesions has a positive outcome in approximately 50% of the patients. Patients should be encouraged to attempt non-operative treatment for approximately 5 weeks. Although our hypothesis was not supported, as compliance did not reach significance, there is a strong trend toward a more compliant patient is more likely to have a positive outcome with non-operative rehabilitation.

Shoulder Muscle Activation In Individuals With Previous Shoulder Injury

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Context: Muscle activation in patients with history of unilateral chronic glenohumeral joint (GHJ) injury may guide clinicians while developing a conservative treatment plan to strengthen or activate specific muscles surrounding the GHJ. **Objective:** To investigate activation via surface electromyography (sEMG) of 6 muscles surrounding the GHJ during functional isometric contractions in individuals with a history of GHJ injury compared to healthy, matched controls. **Design:** Case-control. **Setting:** Research laboratory. **Patients or Other Participants:** 17 individuals with self-reported unilateral GHJ injury (8 women, 9 men, age: 22.3±2.6 years, height: 172.4±8.8 cm, mass: 75.4±16.5 kg, Western Ontario Shoulder Index (WOSI): 618.9±348.348.2) and 17 matched controls with no history of shoulder pain or injury (8 women, 9 men, age 22.9±3.9 years, height: 170.9±11.3 cm, mass: 73.6±22.9 kg, WOSI: 35.1±62.4). **Interventions:** Diagnostic ultrasound images of the supraspinatus were taken in relaxed and contracted states. Manual muscle tests (MMT) were performed in a random order consisting of maximal isometric voluntary contractions of the anterior deltoid, upper trapezius, infraspinatus, lower trapezius, and serratus anterior for normalization values. We then measured sEMG from each muscle while subjects performed 3 5-second

isometric test contractions in an upright-seated position and the arm horizontal to the floor. The test contractions were forward flexion, scapular plane flexion (i.e. scaption) and abduction, all at 90°. **Main Outcome Measures:** Root mean square (RMS) on 5 muscles (anterior deltoid, upper trapezius, infraspinatus, lower trapezius, and serratus anterior) and ultrasound thickness change [(resting thickness – contracted thickness)/ resting thickness] of the supraspinatus were the dependent variables. We normalized sEMG to the ipsilateral side to account for side-side differences inherent in upper extremity musculature. Data were not normally distributed so we used Mann-Whitney U tests to compare RMS sEMG activity and US thickness change scores in injured and healthy joints and Wilcoxon signed-rank test for comparison of injured to uninjured sides within the injured group. **Results:** The anterior deltoid was significantly less activated during the isometric abduction in injured subjects compared to healthy subjects (control: 1.18±0.63, injured: 0.76±0.28, P=.018). In injured subjects, the involved limb lower trapezius was significantly less activated during scaption (healthy: 2.51±1.31, injured: 2.18±.80, P=.022) and abduction (healthy: 4.71±5.3, injured: 3.19±.10, P=.031) compared to the contralateral side. There were no significant differences in other muscles during the three isometric tasks or supraspinatus thickness change between groups or within the injured group. **Conclusions:** Patients with GHJ injury had less activated anterior deltoid muscles compared to controls and exhibited reduced lower trapezius sEMG activation compared to their own contralateral side. The Since these muscles have been proposed to work synergistically in providing GHJ stability, deficits in activation may help guide clinicians in developing exercises that may help improve activation of these muscles in patients with chronic GHJ injury.

A Comparison of Scapular Muscle Strength and Activation in Patients With and Without Glenohumeral Joint Pathology and Scapular Dyskinesis

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Context: Scapular dyskinesis in patients with glenohumeral (GH) pathology is associated with alterations in strength and activation of upper trapezius (UT), middle trapezius (MT), lower trapezius (LT), and serratus anterior (SA), which may compromise scapular stability and function. Weighted forward shoulder flexion (WSFS) is a clinical assessment for determining presence of scapular dyskinesis. It is unknown which muscle alterations best predict scapular dyskinesis. **Objective**: 1) Determine whether scapular muscle strength and activation differ between subjects with and without GH pathology and scapular dyskinesis; 2) Identify muscle strength and activation variables that predict scapular dyskinesis. **Design**: Cross-sectional. **Setting**: Laboratory. **Patients or Other Participants**: Forty-two subjects (GH pathology: n=20; Healthy: n=22; Male: n=17; Female: n=25; Age: 24.2±3.3yrs; Height: 171.7±9.9cm; Mass: 73.4±14.3kg) of convenience were tested. **Interventions**: Subjects performed 10 repetitions of WSFS (females: 2.3kg; males: 4.5kg) while recording muscle activity and visually assessing for normal or abnormal (dyskinesis) scapular motion. For objective 1, the independent variables were status (pathology, healthy) and scapular motion (normal, dyskinesis). For objective 2, the predictor variables were: strength of UT, MT, LT, and SA and integrated electromyography (iEMG) of UT, MT, LT, and SA during concentric and eccentric phases of WFSF. **Main Outcome Measures**: Electromyography (EMG, Noraxon USA Inc, Scottsdale, AZ) was collected from UT, MT, LT, and SA during concentric and eccentric phases of WFSF. iEMG was normalized to maximum voluntary isometric contraction (%·s). UT, MT, LT, and SA strength (kg) was measured during standardized manual muscle tests (MMTs) using a hand-held dynamometer. For objective 1, data were analyzed using 2-way ANOVAs. For objective 2, the predictor variable was scapular dyskinesis (yes, no). A logistic regression was used to identify variables associated with scapular dyskinesis. Alpha was set at d"0.05, two-tailed. **Results**: Twenty-six (62%, pathology=11, healthy=15) subjects displayed normal scapular motion and 16 (38%, pathology=9, healthy=7) displayed scapular dyskinesis. Scapular dyskinesis subjects displayed more SA (32.9±5.7 vs 28.5±5.5 kg, p=0.021) and LT (14.4±4.4 vs 11.7± 4.0 kg, p=0.055) strength compared to normal scapular motion subjects. Scapular dyskinesis subjects displayed lower UT activation during concentric (1491.9±689.4 vs 2817.5±1942.0%·s, p=0.015) and eccentric (996.7±484.4 vs 1672.1±997.7%·s, p=0.015) phases of WFSF compared to normal scapular motion subjects. The best predictor variables of scapular dyskinesis were SA strength [p=0.045, OR=1.15, 95% C.I. (1.00 to 1.32)] and eccentric UT activation during the WFSF [p=0.041, OR=.998, 95% C.I. (.997 to 1.000), accounting for 36% of the variance. **Conclusions**: Scapular dyskinesis subjects generated more SA and LT strength and lower UT activation than normal scapular motion subjects. Higher SA strength and lower UT activity are predictors of scapular dyskinesis. These results present a unique profile of specific scapular muscle strength and activation variables that contribute most to scapular dyskinesis, regardless of injury status.

The Contribution of the Biceps Brachii on Glenohumeral Muscle Activation

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Context: Due to its anatomic location, the biceps-labral complex is subjected to compressive and tensile forces during overhead movements, which can contribute to biceps tendon and glenoid labral pathologies. These injuries are commonly treated surgically by releasing (tenotomy) or relocating (tenodesis) the long head of the biceps tendon from its origin on the superior glenoid. Controversy exists whether these procedures influence shoulder function since the active role of biceps brachii inglenohumeral movement remains unclear. **Objective:** To assess theactiverole of the biceps brachii during glenohumeralelevation tasksby observing the activation of gleno-humeral muscles before and after decreasing active contribution of the biceps brachii through induced elbow flexion fatigue. **Design:** Randomized control trial. **Setting:** Research Laboratory. **Patients or Other Participants:** Thirty individuals with no history of upper extremity injury in the past 6 months were randomized into experimental (n=15, 7 males/8 females, age: 19.9±1.1yrs; mass: 72.9±11.8kg, height: 1.7±0.9m) and control groups (n=15, 8 males/7 females, age: x20.9±1.9yrs; mass: 70.5±8.0kg, height: 1.7±1.0m). **Interventions:** Assessment ofactivity of the biceps brachii and glenohumeral muscles (anterior deltoid, middle deltoid, posterior deltoid, and infraspinatus) during shoulder elevation tasks (flexion and scaption) were repeated before and after the fatigue protocol was introduced only to experimental group participants. Experimental group participants performed three repeated sets of concentric elbow flexion tasks untilfatigue was reached in each set (torque output dropped below 50% maximal torque for three consecutive repetitions) on an isokinetic dynamometer (180°/sec). Shoulder flexion/abduction and elbow flexion strengthwere measured using a hand-held dynamometer before and after the intervention to verify fatigue of the biceps brachii in experimental group participants. **Main Outcome Measures:** Changes in mean activation levels of the biceps brachii and glenohumeral muscles during 0°-30°, 30°-60°, 60°-90°, and 90°-120° of elevation arcs during the elevationtasks before and after the intervention were compared between two groups using a 2-way mixed model ANOVA and post hoc analyses. The changes in three-trial mean of the shoulder flexion/abduction and elbow strength between the experimental and control groups were compared using independent t-tests. **Results:** Despite a significant decrease in elbow flexion strength that was observed after intervention in the experimental group($F_{(1,28)}$=41.5, $p < 0.01$), there were no significant changes inmuscle activity between pre and post fatigue in the experimental or control group across all muscles examined for both flexion and scaption tasks ($p > 0.05$). **Conclusions:** The results indicate that the active contribution of the biceps is minimal during the glenohumeral elevation tasks. It appears that the surgical procedures that relocate or release the biceps tendon from the glenohumeral joint to treat biceps-labral complex can be performed without affecting the activation of the other shoulder musculature.

Free Communications, Oral Presentations: Modifiable Factors of Lower Extremity Injury

Friday, June 29, 2012, 1:15PM-2:30PM, Room 274; Moderator: Steve Zinder, PhD, ATC

Modifiable Biomechanical Factors Predict Total Lower Extremity Initial Energy Absorption During Landing

Norcross MF, Lewek MD, Padua DA, Shultz SJ, Weinhold PS, Blackburn JT: University of North Carolina at Chapel Hill, Chapel Hill, NC; Oregon State University, Corvallis, OR; University of North Carolina at Greensboro, Greensboro, NC

Context: Greater total sagittal plane energy absorption during the 100 ms immediately following ground contact (Total_INI_EA) is representative of a biomechanical landing profile that likely results in greater ACL loading due to sagittal plane mechanisms. However, it is unknown what modifiable biomechanical factors are predictive of Total_INI_EA , and could be targeted in ACL-injury prevention programs. **Objective:** To identify modifiable biomechanical predictors of Total_INI_EA. **Design:** Cross-sectional. **Setting:** Research laboratory. **Patients or Other Participants:** Seventy-seven healthy, recreationally active volunteers (40 M, 37 F; Age = 20.8±2.2 years, Height = 174.4±9.6 cm, Mass = 70.3±16.2 kg). **Interventions:** Peak forces and electromyographic(EMG) amplitudes were measured during hip and knee extension, knee flexion, and ankle extension (plantarflexion) maximal voluntary isometric contractions (MVIC). Subjects then performed double-leg jump landings during which dominant limb EMG and three-dimensional kinematics and kinetics were assessedusing an electromagnetic motion capture system and force plate.**Main Outcome Measures**: Peak forcesmeasured during MVICs using a handheld dynamometer were multiplied by segment length to calculate peak torques, and normalized to the product of subject height and weight. Hip, knee, and ankle joint angularvelocities were multiplied by net internal joint moments calculated using inverse dynamics to produce net joint power curves during the landing task. Individual joint initial energy absorptions (INI_EA), calculated by integrating the negative portions of the joint power curves during the 100 ms following initial contact (IC), were summated to calculate Total_INI_EA. Sagittal plane hip, knee, and ankle angles at IC; sagittal plane angular displacements during the loading phase; and gluteus maximus, quad-riceps, hamstrings, and gastrocnemius mean RMS EMG amplitudes from 50 ms before to 100 ms after IC, normalized to %MVIC ,were also calculated. Four participants identified as outliers on at least one outcome measure during data screening were excluded from further analysis. Factor reduction of the fourteen bio-mechanical measures (i.e. strength, EMG, angles at IC, and angular displacements) was achieved using a principal component analysis. Five principal components (PC) with eigenvalues greater than one were retained, and Anderson-Rubin component scoreswere generated and entered into a forward stepwise linear regression model to predict Total_INI_EA. **Results**: Greater scores for PC1, characterized by greater ankle extension and lesser knee and hip flexion at IC, and greater ankle flexion displacement, significantly predicted greater Total_INI_EA(Adjusted R= 0.056, p=0.024).**Conclusion**:Lesser concomitant hip and knee flexion at IC, greater ankle extension at IC, and greater ankle flexion displacement during landing facilitates greater Total_INI_EA, and thus potentially increases ACL loading. However, as only 5.6% of the variance in Total_INI_EA was accounted for by this model, future research should evaluate the predictive value of these biomechanical factors for individual joint INI_EA, and how changes in specific joint INI_EA may affect Total_INI_EA. Funded by the NATA Foundation Doctoral Grant Program.

Biomechanical Predictors of Peak Proximal Anterior Tibial Shear Force Pre- and Post-Fatigue

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Context: Peak proximal anterior tibial shear force (PPATSF) represents the internal force that directly stresses the anterior cruciate ligament (ACL). Previous studies have examined which biomechanical factors predict higher levels of PPATSF during jump-landing. No studies have examined which factors may increase PPATSF during unanticipated cutting under both fatigued and non-fatigued conditions, which may represent higher-risk situations for ACL injury. **Objective**: To determine the relationships between biomechanical variables and PPATSF under fatigued and non-fatigued conditions during an unanticipated sidestep cutting task (CUT). **Design**: Cross-sectional. **Setting**: Research laboratory. **Patients of Other Participants**: Twenty-seven healthy club-sport athletes volunteered for the study (14F, 13M, height=1.75±0.08m, mass= 69.44 ±9.76kg, age=19.48±1.74years). **Interventions**: The CUT involved a jump over a hurdle, triggering a randomized directional cue. The participant landed with the dominant foot on a forceplate and cut 60° in the indicated direction. Participants then performed the fatigue protocol, which consisted of sprints, side-shuffles, back-peddling, and standing broad jumps. The CUT testing procedures were repeated post-fatigue. **Main Outcome Measures**: A 7-camera motion capture system and forceplate were used for data collection. The following variables were calculated: Ankle ($ankle_{IC}$), knee ($knee_{IC}$), hip (hip_{IC}), and trunk ($trunk_{IC}$) flexion at IC; ankle ($ankle_{PPATSF}$), knee ($knee_{PPATSF}$), hip (hip_{PPATSF}), and trunk ($trunk_{PPATSF}$)

flexion, vertical ground reaction force (VGRF) ($VGRF_{PPATSF}$), posterior ground reaction force (PGRF) ($PGRF_{PPATSF}$), and knee extension moment (KEM) (KEM_{PPATSF}) at PPATSF; and peak values of ankle dorsiflexion ($ankle_{Peak}$), knee ($knee_{Peak}$), hip (hip_{Peak}), and trunk ($trunk_{Peak}$) flexion, VGRF ($VGRF_{Peak}$), PGRF ($PGRF_{Peak}$), and KEM (KEM_{Peak}). Force variables were normalized to body mass (%BM), and KEM normalized to body mass*body height (%BM*BH). Pairwise Pearson correlations with PPATSF, and stepwise linear regression analyses with PPATSF as the criterion variable, were calculated pre- and post-fatigue (≤ 0.05, regression entry criterion $P \leq 0.05$). **Results**: Pre-fatigue, significant correlations existed between PPATSF (0.19±0.09%BM) and $knee_{PPATSF}$ (20.0±5.5°, R=-0.685, $P<0.001$), $VGRF_{Peak}$ (3.11±0.58%BM, R=0.584, $P=0.001$), $VGRF_{PPATSF}$ (1.10±0.49%BM, R=0.396, $P=0.041$), $PGRF_{PPATSF}$ (-0.38±0.28%BM, R=-0.393, $P=0.043$), and $PGRF_{Peak}$ (-0.63±0.32%BM, R=-0.380, $P=0.050$). $Knee_{PPATSF}$, $VGRF_{peak}$, $ankle_{IC}$, and $knee_{IC}$ predicted 77.6% of the variance in PPATSF ($F_{4,22}=19.076$, $P<0.001$). Post-fatigue, significant correlations existed between PPATSF (0.24±0.07%BM) and $VGRF_{PPTASF}$ (0.95±0.46%BM, R=0.450, $P=0.019$) and $ankle_{Peak}$ (-3.19±6.54°, R=-0.400, $P=0.039$). $VGRF_{PPATSF}$ predicted 20.3% of the variance in PPATSF ($F_{1,25}=6.348$, $P=0.019$). **Conclusions**: Fatigue appears to alter the relationships between PPATSF and several kinematic and kinetic variables. Post-fatigue, the moderate correlation between ankle dorsiflexion angle and PPATSF, and the loss of any correlation between knee flexion and PPATSF, suggests an altered neuromuscular response to activity. Other factors account for almost 80% of the variance in PPATSF post-fatigue, suggesting neuromuscular variables not captured in this study may play a greater role in developing PPATSF under fatigued conditions. ACL injury prevention programs should consider taking alternate approaches to reducing PPATSF and ACL strain under fatigued and non-fatigued conditions.

Relationships between Hip Muscle Stiffness and Kinematic Factors Associated with ACL Injury

Cram TR, Norcross MF, Padua DA, Blackburn JT: University of North Carolina at Chapel Hill, Chapel Hill, NC

Context: Proper hip neuromuscular control is important for sound knee kinematics during dynamic tasks. Excessive knee valgus motion results in ACL loading and is a prospective ACL injury risk factor. The hip musculature purportedly limits knee valgus motion by eccentrically resisting hip adduction and internal rotation, but the literature regarding the influences of hip muscle strength and activation on frontal plane knee loading is equivocal. Stiffness quantifies a muscle's ability to resist lengthening, thus greater hip muscle stiffness may limit ACL loading and injury riskby limiting hip adduction and internal rotation, and therefore, knee valgus. **Objective:** To explore the relationships between hip muscle stiffness and lower extremity kinematics during a dynamic task. We hypothesized that individuals with greater hip abductor and extensor stiffness would display lesserknee valgus motion during a jump landing task.**Design:**Cross-sectional. **Setting:** Research laboratory. **Participants:** Forty healthy,recreationally active volunteers (20 males, 20 females; age= 20±2years, height= 173±9cm, mass= 71±15kg) participated in this investigation. **Intervention:**Hip abductor and extensor stiffness were assessed from the damping effect these muscle groups imposed on oscillatory hip motion following perturbation.Hip and knee kinematics were assessed during a double-leg jump landing task via an electromagnetic motion capture system. **Main Outcome Measures:**Hip muscle stiffness was normalized to subject mass ($N/m \cdot kg^{-1}$). Knee valgus angles at initial ground contact, peakvalgus angles, and valgus angular displacements during the loading phase of the jump landing task were calculated. Simple correlations were used to evaluate relationships between hip muscle stiffness and each kinematic variable. Multiple linear regression was also used to evaluate the relationships between the combination of hip abductor and extensor stiffness and each measure of knee valgus motion. **Results:** Individuals with greater hip abductor stiffness displayed lesser peak knee valgus angles ($r = 0.266$, $p= 0.048$) and valgus angular displacement ($r = 0.370$, $p= 0.009$). Hip extensor stiffness in isolation was not correlated with knee valgus motion. However,the linear combination of hip extensor and abductor stiffness predicted 36% of the variance in knee valgus angle at initial ground contact ($p< 0.001$) and 29.8% of the variance in knee valgus displacement ($p = 0.006$), and the multiple regression model for peak knee valgus angle approached statistical significance ($R = 0.154$, $p = 0.065$). **Conclusions:** Our findings suggest a link between hip muscle stiffness and knee valgus motion. Specifically, individuals with greater hip muscle stiffness display lower extremity biomechanics which may place them at a lesser risk of ACL injury compared to individuals with more compliant hip musculature. Muscle stiffness can be altered via training, thus enhancing hip muscle stiffness may be an important addition to future ACL injury prevention programs.

There are No Sex Differences in the Landing Biomechanics of Youth Soccer Athletes

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Context: Postpubertal females have been shown to have different landing biomechanics than males, which may put them at increased risk for ACL injury. Limited knowledge is available regarding sex differences and landing biomechanics in younger populations. **Objective:** To determine if there are sex differences in youth soccer athletes' landing biomechanics. **Design:** Cross-

sectional. **Setting:** Research laboratory. **Participants:** Sixty healthy soccer athletes (females: n=25, age=10±1 years,height=140.34±6.48cm, mass=33.06±5.03kg; males: n=35, age=10±1 years, height=143.03±6.23cm, mass=34.42±5.34kg) volunteered to participate. **Interventions:** One set of three trials of a jump-landing task was performed during a single test session. The task required participants to jump forward from a 30cm high box placed a distance of half their height away from a force plate, land with their dominant foot on the force plate, and immediately jump for maximal vertical height. An optical three-dimensional motion analysis system and a force plate measured lower extremity kinematics and kinetics. **Main Outcome Measures:** Dependent variables included sagittal and frontal plane knee angles at initial contact and peak values over the stance phase. Peak vertical (VGRF), posterior (PGRF), and anterior (AGRF) ground reaction forces (PGRF), internal knee extension moment, and external knee valgus moment over the stance phase were also measured. Forces were normalized to body weight and moments were normalized to body weight and height. Separate one-way analyses of variance were performed on the dependent variables to assess group differences between males and females ($\alpha \leq .05$) and descriptive statistics were used to identify mean values. **Results:** No significant differences were observed (P>0.05) in our main outcome measures. A descriptive analysis of kinematic variables revealed that at initial contact participants landed with 17.96±6.3° of knee flexion and 0.537±3.77° of knee valgus and peaked at 76.23±9.11° of knee flexion and 5.51±8.21° of knee valgus during the jump landing task. Descriptive analysis of normalized peak kinetic variables revealed VGRF= 3.59 ±0.786%BW, AGRF= 0.383± 0.253% BW, and PGRF=-1.32± 0.318%BW. **Conclusion:** Male and female prepubertal soccer players are not significantly different in their biomechanical landing strategies and tend to land in an extended knee position. This suggests that injury prevention programs should be implemented in this age group to encourage proper landing technique before sex differences emerge.

Changes in Sagittal Plane Kinematics during Jump Landing Immediately Following Implementation of Real Time Feedback

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Context: Suboptimal lower extremity biomechanics during jump-landing may lead to various lower extremity joint injuries. Clinician provided feedback has positively altered landing biomechanics in the frontal and sagittal planes. However, the use of technology in an effort to allow the participant to make real time biomechanical adjustments during landing has not been evaluated. **Objective:** Determine the immediate effects of real time feedback (RTF) and traditional feedback (TF) on sagittal and frontal plane landing kinematics compared to a control condition. **Design:** Single blinded, randomized controlled trial. **Setting:** Research laboratory. **Patients or other Participants:** Twenty-two physically active females with no history of lower extremity injury were randomized into 3 groups (RTF: n=7, 21.0±1.5yrs, 165.5±5.6cm, 65.0±8.8kg; TF: n=7, 20.7±2.2yrs, 165.1±5.5cm, 62.0±3.5kg; Control: n=8, 21.25±1.2yrs, 162.6±6.8cm, 66.0±18.5kg). **Interventions:** RTF and TF participants completed three sets of six jump-landing trials (18 total) off a 30cm box. Both intervention groups were provided standardized feedback, using verbal cues and visual representation of correct landing biomechanics, from a single clinician pertaining to each set of jumps. Additionally, participants in the RTF group were equipped with retroreflective markers positioned on the lower extremity and lower extremity kinematics were analyzed with 3-dimentional Motion Analysis software. Markers on the patella and dorsum of the great toe were highlighted, and connected with a segmental line. RTF participants visualized their 3-dimensional model on a 107cm monitor, and were instructed to align the highlighted knee-foot segment with a stationary vertical reference line in the frontal plane during landing. Control participants received no feedback and sat quietly for 10 minutes. **Main Outcome Measures:** Participants performed three pre-intervention jumps and three post-intervention jumps consisting of a forward jump off a 30cm box transitioning into a maximal vertical jump. Change scores from baseline were calculated for all three groups. A one-way ANOVA with Tukey post hoc comparisons and standardized effect sizes (Cohen's *d*) with 95% confidence intervals (CI) were used to assess change scores in hip flexion, knee flexion and knee abduction angles. Alpha was set a priori at P<0.05. **Results:** A significant difference was observed between groups for hip flexion ($F_{2,19}$=4.63, P=0.02) and knee flexion ($F_{2,19}$=10.02, P=0.001). Hip flexion in the TF group (5.95±8.17) was greater than the control (-2.16±3.01, P=0.03, d=1.36, CI: 0.16, 2.39). Knee flexion was greater for TF (11.199±10.06, P=0.001, d=2.08, CI:1.96,0.63) and RTF (6.93±5.82, P=0.015, d=2.27, CI: 2.14, 0.65) compared to controls (-4.33±4.07). Knee abduction was not significant between groups ($F_{2,19}$=2.10, P=0.15).**Conclusion:** Both RTF and TF had a significant immediate effect on sagittal plane landing biomechanics compared to control, while changes in the frontal plane were not significantly different. Fontal plane changes may require more training in order for participants to make changes in landing strategies.

Congenital Absence of Pectoralis Major in a High School Athlete

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Background: Athlete is a 16-year old right-handed male high school football athlete. Athlete reported to Athletic Trainer (ATC) post practice complaining of his left shoulder "popping in and out" during practice contact drills. Athlete denies any prior shoulder history or problems. Athlete was examined by ATC. Physical examination revealed concavity of the left pectoral region with no other deformities noted. Athlete was point tender over the anterior shoulder complex, biceps tendon and posterior joint capsule with mild swelling noted. Obvious weakness and pain were noted in active and resistive shoulder flexion, extension and internal and external rotation, other weakness noted in biceps flexion and horizontal adduction. Orthopedic special testes revealed (-) Anterior Apprehension test, (+) Posterior Apprehension test, (+) Relocation test for pain, (-) Speed's Test, (+) Crank Test. **Differential Diagnosis:** Biceps Strain, Rotator Cuff Strain, Glenohumeral Subluxation, Labrum Pathology, 3rd degree Pectoralis Strain **Treatment:** Initial treatment consisted of pain and swelling control through ice and electrical modalities. The athlete was then referred to Team Physician. Diagnostic imaging consisted of X-ray and MRI which revealed a congenital absence of the sternal portion of the pectoralis major. MRI further revealedBankart lesion of the Glenoid Labrum with accompanying swelling indicating Posterior Glenohumeral joint sprain. Athlete was treated conservatively for two weeks with progressing strength and range of motion (ROM) exercises. The athlete was then able to return to participation with treatment and rehabilitation continued to address strength deficits and to continue to decrease athlete's signs and symptoms. For competition and practice, athlete wore a Sully Shoulder Stabilizer the remainder of the season. Following the regular season, athlete underwent arthroscopic surgery to repair Bankart Lesion The athlete underwent extensive rehabilitation following surgery and has made a full recovery. Athlete still presented with left horizontal adduction strength deficit. **Uniqueness:** Shoulder subluxations and accompanying Labrum tears are injuries often seen in the athletic population; however, the congenital absence of a muscle is rare. A review of the literature did indicate that the most frequently involved muscle that is congenitally absent is the pectoralis muscle with the congenital absence of the trapezius muscle a distant second. As indicated in this case, a contributing factor to the initial shoulder subluxation was the lacking anterior musculature which led to altered mechanics at the Glenohumeral joint making the athlete susceptible to shoulder injury. The lack of anterior shoulder musculature was a contributing factor for the posterior shoulder joint injury. A review of the literature suggested that those individuals suffering from a congenital absence of the pectoralis have demonstrated, on isokinetic testing, a 20-30% decrease in shoulder horizontal adduction strength with even larger strength deficits noted when the congenital abnormality affected the non-dominant shoulder. **Conclusions:** This case highlights an athlete suffering from a posterior shoulder joint pathology and subsequent Bankart Lesion of the Glenoid Labrum. It also highlights the athlete who presented with a congenital absence of the Pectoralis Major Muscle that was participating asympto-matically prior to the posterior shoulder injury. As noted, the absence of the muscle did produce a horizontal adduction strength deficit that was believed to be associated with the shoulder injury. The athlete has made a full recovery post surgically.

Asymptomatic Juvenile Osteochondritis Dissecans in a Middle School Athlete

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Background: A 12 year-old male middle school football athlete with no past medical history of knee injuries, was tackled by two teammates during football practice on 8/16/11, forcing his right tibia into internal rotation. He reported feeling and hearing a "pop" at moment the right knee impacted the ground. On field evaluation revealed active and passive knee ROM were WNL bilaterally. Inspection and palpation revealed no gross deformity, with swelling and tenderness over the medial and lateral tibiofemoral joint lines. Varus/valgus stress test, anterior drawer, posterior drawer, and Lachman's, were all negative for laxity but positive for pain. After being assisted off the field, active and passive ROM of the right knee were significantly diminished, and no further special tests were performed due to pain. After evaluation, he was given an ACE wrap, ice, crutches and instructed to make an appointment with a physician the next morning. **Differential Diagnosis:** Bone contusion, medial/lateral mensical tear, MCL sprain, LCL sprain. **Treatment:** Physician's exam of the right knee revealed a mild effusion, 0-100º ROM, lateral joint line pain, patellar border pain, and a positive McMurray's test. Lachman's, anterior/posterior drawer, and varus/valgus stress tests were all negative. Attending fellow and physician suspected a meniscal tear after the exam and review of negative radiographs. Same day MRI revealed medial femoral condyle bone bruise with low-grade sprain of medial collateral ligament, partial thickness tear of popliteus tendon and popliteus sprain at myotendinous junction, and a low-grade sprain of lateral collateral ligament. In addition, the athlete had

an insidious but stable osteochondritis dissecans the lateral aspect of the medial femoral condyle, with overlying cartilage intact that was unrelated to the injury. Final injury diagnosis was posterolateral corner sprain with anteromedial bone contusion. The patient was fitted for a TROM brace locked in full extension, non-weight bearing on crutches. On 8/24/11, therapy commenced with the brace in full extension. On 9/08/11, the athlete exhibited knee ROM from 0-130 º, with no instability or increased swelling since first visit, and the brace was then unlocked for daily ambulation in the TROM. On 10/5/11, the patient had gained full AROM and began agility exercises. He was cleared to return to play on 10/19/11, provided he wore a hinged knee brace. **Uniqueness:** Juvenile osteochondritis dissecans (JOCD) presents with vague knee pain and occasional mechanical symptoms, such as popping and locking. Diagnosis can take up to 14 months due to the mild pain with which patients present. It is more prevalent in males, with the most common site for OCD being the lateral aspect of the medial femoral condyle, affecting up to 70 percent of patients. This patient's asymptomatic JOCD was discovered after he suffered acute knee internal trauma, allowing it to be treated before it progressed. **Conclusions:** JOCD does not consistently appear on radiographs; therefore MRI is the accepted imaging in literature for diagnosing lesions. However, there are no established clinical guidelines for the treatment of JOCD lesions. Treatment for stable lesions is activity restriction and immobilization based on symptoms. Nonoperative protocols are reported to have success rates of 50-94 percent. This patient was treated conservatively with immobilization and activity restriction to treat both acute and insidious knee injuries. He successfully participated in his first football game on 10/25/11. Athletic trainers working with sports that expose athletes to repetitive trauma and shear forces should be aware that these are contributing mechanisms to OCD. It is important that athletic trainers recognize the signs and symptoms of the insidious disease, and do not rule out JOCD as a diagnosis for chronic mild knee pain.

Long-Standing, Recurrent Foot and Ankle Pain in an Adolescent Athlete

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Background: In October 2009, a 13 year-old volleyball athlete presented with right ankle pain.She had a history of 2 lateral ankle sprains sustained in October 2008. Subsequently, she hadongoingpain over the Achilles tendon insertion and anteriortalofibular ligament (ATFL). Evaluation revealed no obvious deformity or discoloration of the lower leg, ankle, or foot. Musculature of the lower-leg was symmetrical bilaterally. She was point tender along the Achilles tendon from the musculotendinous junctionto insertion, ATFL, and plantar fascia. Active and resistive ankle ROMs wereWNL, with pain during plantar flexion and toe flexion. Passive dorsiflexion produced pain.Anterior drawer, Thompson test, talar tilt, and navicular drop evaluationwere negative. On referral, physician evaluation revealed tenderness over the ATFL, Achilles tendon insertion, and plantar fascia,with decreased dorsiflexion. Radiographs were normal, with no evidence of fracture or degenerative changes. Magnetic resonance imaging (MRI)revealed mild tendinosis of the peroneus longus tendon, and an os trigonum. She was diagnosed with plantar fasciitis, posterior impingement,Sever's Disease, and residual ATFL discomfort. She was placed in a walking boot for 4 weeks, prescribed physical rehabilitation, and permitted to participate as tolerated without the boot. In March 2010,symptoms returned following softball tryouts. Physician re-examinationrevealed that current diagnoses were consistent with prior.She was again placed in a walking boot and referredto a foot and ankle specialist.This evaluation in May 2010 revealed noticeable calf atrophyand tenderness over the anteriomedial and anterolateral ankle, Achilles insertion, and foot dorsum. Pain was noted at rest and walking on heels and toes.Radiographs revealed no abnormalities and a repeat MRI was not ordered. Athlete was again diagnosed with Sever's disease and prescribed 12 weeks ofphysical rehabilitation. At completion, she had good improvement, no pain over the Achilles, andwas released for gradual return to sportswith follow-up as needed.In October 2010, she presented again with similar pain (7-9/10) in her right foot and ankle.Pain was present at rest and with palpation in the Achilles tendon, medial arch, posterior tibialis tendon, and navicular. There was no significant edema or deformity. **Differential Diagnosis:** Achilles tendinopathy, plantar fasciitis, posterior impingement, Sever's disease, stress fractures. **Treatment:**MRI revealed persistent patchy osteoedema with subtle "picture frame" appearance of the distial tibia, tarsals (calcaneus, cuneiforms, navicular, and cuboids), with small focal capsulitis of the metatarsophalangeal joints. The athlete was diagnosed with Reflex Sympathetic Dystrophy (RSD). She was referred to a pediatric orthopedist and was further diagnosed with Type I RSD. **Uniqueness:**Type I RSD, also known complex regional pain syndrome (CRPS), is a rare, chronic, progressive disease that is the result of an injury or immobilization, with no identifiable nerve damage. It is characterized by pain disproportionate to theinjury with swelling and neurovascular changes in the affected area. Rareamong children, the average diagnosis age is 42 years. Pathophysiology is not completely understood, but central nervous system hypersensitization, surgery, immune processes, and musculoskeletal injury, may be contributing factors. Additionally, RSD has been postulated as a differential diagnoses among adolescents with Sever's Disease. Radiographs typically reveal patchy osteoporosis, but changesseen between tendinitis to patchy osteoedema between the initial and

repeat MRI shows the progressive, physiologic changes not seen by plain radiographs.**Conclusions:** The rarity and complexity of RSD leaves athletic trainers with a lack of familiarity and understanding of its clinical presentation. For a patient who fails to improve with treatment, persistent pain conditions, such as RSD, must be considered. Prognosis tends to be better with early diagnosis of RSD, and subsequent appropriate treatment tends to lead to better patient outcomes.

Elbow Injury in an Adolescent Baseball Player

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Background: A 12yo baseball player with no history of upper extremity injury presented with a primary complaint of forearm and elbow 7/10 pain after being hit by a pitch. There was no obvious deformity by visual inspection or palpation. He was point tender about the proximal ulna at the site of contact. The athlete had full active and passive ROM of the shoulder, elbow and wrist. However, ROM of the elbow was painful. . There was not a report of numbness or pain radiating to the hand. Initial treatment consisted of ice and over the counter analgesics for treatment of swelling and pain, and activity as tolerated. **Differential Diagnosis**: Contusion, Ulna fracture, UCL Sprain, Epicondylitis **Treatment:** The athlete was referred to a primary care sports medicine physician 10 days post injury. At that time the athlete reported continued but lessening pain 2/10 that increased with throwing. The physician exam revealed mild swelling about the elbow with pain focused in the forearm. Distal pulses were 2+ and sensation was intact throughout the upper extremity. Flexion, extension, pronation, and supination of the wrist were full and pain free. Elbow ROM was full, however, hyperextension was painful. Varus and Valgus maneuvers did not elicit pain or instability of the elbow at 0°, 30°, or 60°. Plain radiographs of the right elbow were ordered by the physician and revealed an incomplete intra-articular fracture of the olecranon and soft tissue swelling about the posterior elbow. It was determined the fracture was chronic and un-related to the recent trauma. The athlete was diagnosed with a forearm contusion and an olecranon stress fracture, placed in a sling, and withheld from athletic activity. A two week follow-up with repeat radiographs was scheduled with an orthopaedic surgeon. This exam revealed the patient was asymptomatic with full ROM and no pain. Plain radiographs showed the lucency to be less clear with an increase in sclerosis along the margins. The orthopaedic confirmed the assessment of an olecranon stress fracture. At this time the treatment plan was to discontinue use of the sling and to allow the athlete to begin football activity at the 1 month mark in a hinged elbow brace for protection. He was instructed to stop activity if any symptoms returned. In addition, it was recommended that the athlete abstained from pitching/throwing for 3 months and follow-up in 1 month with the primary care sports medicine physician. At the 2 month follow-up exam the follow-up xrays revealed interval healing of the fracture site. In addition, the athlete reported he tolerated football activity and remained asymptomatic. The athlete was released to football activity as tolerated in the brace and refrain from pitching/throwing. The athlete was not planning to participate in baseball through the winter follow-up was scheduled for 2 months. At that time radiographs showed a healed fracture. The athlete was released to play basketball and will be begin a throwing program at 6 months. **Uniqueness:** An asymptomatic stress fracture was diagnosed due to an unrelated injury in a young adolescent athlete. Due to the incomplete nature of the stress fracture this was able to heal without surgical intervention. Had this not been detected early, the fracture would have likely worsened requiring fixation due to the athlete's participation in sporting activities. Also as stress reactions and fractures are typically seen in an older population. **Conclusion**: With the increasing popularity of competitive sports at younger ages, it is important to be aware of stress and overuse injuries in a pediatric population. These stresses to skeletally immature bones can lead to more serious injuries in this population.

Foot Drop in a Growing Athlete

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Background: 10y/o male soccer player presents two weeks after the insidious onset of foot drop. The athlete recalls two months of anterolateral leg and knee pain after playing soccer. Physical exam of cardiovascular, spine, and upper extremities are normal and symmetrical. Obvious steppage gait is noted with no antalgia. No visible or palpable deformities are about the spine or the affected lower extremity. There is no evidence of muscle contraction (0/5) of the tibialis anterior (TA) or extensor hallucis longus (EHL) muscles of the left lower leg. Ankle eversion strength is slightly weak (-4/5) with normal strength of the posterior tibialis and flexor hallucis longus muscles. Reflexes are normal. Sensory testing reveals abnormal sensation to light-touch in the dorsum of the foot and first web space. Percussion and compression of the popliteal fossa creates radiating discomfort down the leg. Ligamentous examination of the knee is normal. Vascular exam is normal. There is no evidence of proximal tibiofibular joint instability. **Differential Diagnosis**: peroneal nerve contusion, anueurysm, tumor, spinal cord lesion **Treatment**: Plain radiographs showed normal physes and no evidence of fracture, dislocation, lytic or blastic lesion about the knee. EMG-NCV results showed high grade peroneal nerve compression. MRI showed an intraneural ganglion cyst of

the common peroneal nerve originating at the proximal tibiofibular joint extending proximally 11.6cm within the common peroneal nerve. Final diagnosis was foot drop due to common peroneal nerve palsy secondary to proximal tibiofibular joint ganglion cyst. Surgical intervention was indicated and included peroneal nerve neurolysis, resection of the articular branch of the common peroneal nerve and decompression of ganglion cyst of peroneal nerve. Post-operatively the athlete was allowed to weight bear with crutches for three weeks with full-time ankle-foot orthosis (AFO) wear. Immediately post-operatively the athlete reported the return of normal sensation throughout the dorsum of the foot. Physical therapy was utilized to regain knee motion, muscle strength and to maintain ankle flexibility. He has no post-operative pain and participates in activities of daily living. TA or EHL muscles have exhibited no signs of return of function at 2months post-operatively but it is estimated to require a minimum of 4 months before fasciculations may be detected due to the length of nerve regeneration required. He is permitted to gradually return to sport as tolerated and is to wear his AFO at all times. **Uniqueness**: Ganglion cysts causing neurological deficits of the lower extremity are rare, highly variable, and difficult to diagnose (Schrijaver et. al, 1998). Of ganglion cysts in the lower extremity, 33% of them involve the knee (Das et. al, 2008). Peripheral nerve compression due to ganglia is rarely reported in the literature, especially of the lower extremity (Greer-Bayramoglu et. al, 1998). Surgical intervention is usually necessary. Nerve recovery is heavily dependent on a timely and accurate diagnosis (Schrijaver et. al, 1998, Greer-Bayramoglu et. al, 1998). Prognosis for return to sport correlates with age, severity of nerve compression, and time to decompression (Schrijaver et. al, 1998). **Conclusions**: The absence of trauma, injury as well as overall presentation of this case raises awareness for the differential diagnoses of foot drop in athletes. Without diagnostic imaging, ganglion cysts are difficult to identify and therefore should always be included in the differential diagnosis as a cause of lower extremity neurologic dysfunction. Early recognition and referral is critical to optimize expedient treatment and the chance for neurologic recovery.

Effect of Exercise Before an Ice Bag Treatment on Quadriceps Interface and Intramuscular Temperatures Following Application

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Context: Ice bags are often applied following exercise. It is known that exercise before cooling speeds heat removal from deep tissues, but it is not known if superficial and deep post-treatment temperatures are affected by the precedingexercise.**Objective:** Determine if exercise before an ice bag Tx effects interface and intramuscular rewarming.**Design:** Cross-over **Setting:** Laboratory. **Participants:** Twelve physically active males (21.8 ± 1.7y, ht: 183.3 ± 8.8cm, mass: 87.4 ± 12.2kg: skinfold: 23.6 ± 3.3mm). **Intervention:** During 2 sessions separated by at least 48 hours participants either rested supine (Rest) or stationary biked (Cycle) at 70%-80% of their Karvonen predicted exercise heart rate for 30 minutes. Immediately following the exercise condition a wetted ice bag (2000mL ice with 300mL water) was compressed to the right anterior mid-thigh until intramuscular temperature was 10°C below baseline. Temperatures were collected immediately after ice bag applicationand every 10 minutes for 120 minutesfollowing application. Independent variables were Exercise Condition (Rest &Cycle), and Time (Immediate, 10, 20, 30, 40, 50, 60, 70, 80, 90, 100, 110, & 120 minutes). **Main Outcome Measures:** Interface and intramuscular (2cm + ½ skinfold) temperatures to the nearest 0.1°C. A*t priori* of .05,repeated measures ANOVAs and Tukey-Kramer MC tests were performed on interface and intramuscular temperatures separ-ately. **Results:** Rest and Cycle intramuscular temperatures took 73 minutes and 31 minutes to reach 10°C below baseline, respectively. Interface temperatures were affected by the interaction of Exercise Condition and Time ($P<$ .001). Interface Cycle Immediate temperature (5.2°C) was 2.2°C warmer than the Rest Immediate temperature ($P<$ .05). Within 10 minutes the interface Cycle temperature (21.4°C) was 4.3°C warmer, and thereafter the difference steadily decreased to 1.2°C at the 120-minute time($P<$.05), where the Cycleinterface temperature was 29.4°C. Intramuscular temperatures were also affected by the interaction of Exercise Condition and Time ($P<$ .001). The intramuscular Cycle temperature sat the Immediate (26.1°C), 10-minute (25.9°C), and 120-minute (32.5°C) timeswere similar to the Rest intramuscular temperature. At the other Times intramuscular Cycle temperatures ranged from 2.2°C-1.2°C warmer than the Rest ($P<$ .05). **Conclusion:** After stationary cycling interface and intramuscular temperatures of the thigh rewarm quicker following a 30-minute, 1-kg wetted ice bag application.

Intramuscular Temperature Changes During and After Two Different Cryotherapy Interventions

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Context: Cryotherapy is commonly used in athletics to treat pain from muscle injuries. Cooler intramuscular (IM) temperatures may reduce metabolism to create a beneficial environment for healing. Cryotherapy modalities that decrease IM temperature quickly may be more beneficial in the treatment of muscle injuries and associated pain. **Objective**: To compare the amount of time required to decrease IM temperature 8°C below baseline temperature, as well as to compare IM temperature 90 min post-treatment using two common cryotherapy modalities, a crushed ice bag (CIB) and cold water immersion (CWI). We hypothesized that CWI would cause IM temperature to decrease in a shorter time and remain lower at the end of a rewarming period. **Design**: Cross-over. **Setting**: Research laboratory. **Patients or Other Participants**: 18 healthy subjects, 7 males (age= 22.8±2.0 years, height=180.3±8.2 cm, mass=84.9 ±17.9 kg, medial calf adipose thickness =1.4±.58 cm) and 11 females (age=21.8 ±1.3 years, height =163.0±4.9 cm, mass=57.3±5.7 kg, medial calf adipose thickness=1.8±.39 cm) volunteered to participate. **Interventions**: Subjects received 2 cryotherapy treatments in a randomly allocated order (CIB or CWI) separated by at least 72 h. CIB consisted of 1500 mL crushed ice in a 38x51 cm flexible plastic bag with excess air evacuated and secured with elastic wrap at a standardized pressure at the medial head of the gastrocnemius. CWI consisted of crushed ice and cold water in a 38 L tub maintained at 12°C and stirred frequently, with the lower leg fully immersed. Each cold modality was applied until IM temperature decreased 8°C below baseline. IM temperature was monitored at the medial head of the gastrocnemius using an implantable thermocouple inserted 1 cm below subcutaneous adipose tissue measured prior to intervention with diagnostic ultrasound. **Main Outcome Measures**: The primary outcome of this study was time to decrease IM temperature 8°C below baseline during each inter-vention. A secondary outcome was IM temperature at the end of a 90 min rewarming period in each condition. Paired t-tests were used to examine time to decrease during intervention and IM temperature after rewarming. **Results**: The time to reach an 8°C reduction in IM

temperature was similar between CIB (44.1±22.7 min) and CWI (39.0±14.8 min, P=.338). IM tempera-ture remained significantly colder at 90 min post-CWI (30.2°C±2.1°C) compared to 90 min post-CIB (32.5°C ±2.9, P=.001). **Conclusions**: There was no difference in the time required to reduce IM temperature 8°C when measured at 1 cm below adipose tissue using CIB and CWI. However, IM temperature remained significantly colder for at least 90 min following CWI intervention. This study provides clinicians with information that may guide treatment modality decisions and allow researchers to begin to develop cryotherapy prescription.

Cryotherapy Durations for a Standard 7°C Decrease in Different Body Parts

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Context: To assess cryotherapy's effectiveness using clinical outcome measures, treatmentsettings must provide a standardized physiological effect, i.e. similar temperature decrease, in all patients. Tissue depth, i.e. overlying skinfold measurement, accounts for ~50% of the temperature decreasevariability during cryotherapy. Based on existingtissue cooling and skinfold data, theoretical cryotherapy duration guidelines were developed to produce a standard 7°C decrease for various body parts. These guidelines need to be validated. **Objective:** The purpose of this study was todetermine the time to decrease muscle and ligamentous temperature 7°C in four body parts in individuals with both high and low skinfold measurements. **Design:** Descriptive laboratory study. **Setting:** Athletic Training Research Laboratory. **Patients or Other Participants:** Twenty-four, healthy adults (F=9, M=15; Age=25±5.6 years;Height=1.75±0.9m; Mass= 81.6±12.5kg) volunteered. Each was stratified into one of two skinfold groups (Low or High) for one of the following body parts: anterior talofibular ligament (ATF), medial calf (Calf), middle deltoid muscle (Delt), or anterior thigh (Thigh). Skinfold groups were specific to the body part and based on existing skinfold data. Individuals withcold allergies, abnormal circulation, abnormal sensation, or reported orthopedic injury in the past 6 months, were excluded. **Interventions:** A 2x4 factorial design guided this study. Independent variables were skinfold group (High v. Low) and body part (ATF, Calf, Delt, or Thigh). An im-plantable thermocouple (Physiotemp, IT-21), connected to an Iso-Thermex,was placed 0.5-cm or 1.0-cm deep to the subcutaneous adipose tissue for the ATF and muscles, respectively. After baseline temperature was established, a 0.75-kg crushed, ice-bagwas secured using an elastic wrap until tissue temperature decreased 7°C. **Main Outcome Measures:** The dependent variable was timeto decrease tissue temperature7°C. Data were analyzed with an ANOVA, followed by Tukey-Kramer post-hoc testing. The *P*-value was set at .05. **Results:**An interaction occurred between skinfold group and body part ($F_{3,16}$=16.04, *P*<.001; β<.001). In the Thigh, the High skinfold group (35.33±17.74-min) took longer to cool than the Low skinfold group (3.00±0.50-min; Tukey-Kramer *P*<.05). The High Thigh group took longer to cool than the High ATF (6.83±7.11min), Delt (13.67±8.75min), and Calf (9.17± 2.0min) groups,as well as the Low ATF (6.83±7.11min), Delt (11.00± 6.00 min), and Calf (18.83± 5.77min) groups (Tukey-Kramer *P*<.05). Regardless of skinfold group, the Thigh took longer to cool (19.17±17.75min) than the Ankle (8.16±6.02min) ($F_{3,16}$=4.17; *P*=.023; β=0.75; Tukey-Kramer *P*<.05). **Conclusions:** Only the thigh requiresdifferent application durations based on tissue depth. To achieve similar tissue cooling, clinicians should use longer cryotherapy durationsfor the thigh than the ankle. In addition, the body part application durations werewithin the proposed application guidelines (ATF 15 min; Calf 15-25 min; Delt: 25-40min; High Thigh: 40 min; Low Thigh: 25 min). Funded by GLATA GordyStoddard Research Assistance Award.

The Effectiveness of 2 Forms of Cryotherapy Through Various Common Barriers

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Context: A therapeutic effect of cryotherapy is pain relief via a decrease in superficial nociceptive fiber conduction. Research literature indicate optimal analgesic effects are established between 13.6-15.6 °C. It can be deduced that the practice of applying an ice bag over a dry barrier would not result in the therapeutic temperature range needed to attain desired physiological effects. **Objective**: The purpose of the study was to examine the effects on skin temperature by two different forms of cryotherapy applied through different barriers (t-shirt, elastic bandage, control). **Design**: Crossover study. **Setting**: Research laboratory. **Patients or Other Participants**: 18 participants (males= 10, females = 8) (age = 23.2 ±3.1 years, mass= 69.7 ±12.2 kg, height= 169.5 ±8.6 cm) with no history of current or recent upper extremity injury. **Interventions**: Independent variables: cryotherapy agent/mode [Game Ready™ (GR), ice bag (IC)] and barrier condition [t-shirt (TS), elastic bandage (EW), control (CO)]. Operational definitions: GR (pressure=off, coldest wrap temper-ature=2 °C), IC (plastic bag filled with approximately 1 kg of crushed ice), TS (agent applied over one layer of a cotton t-shirt sleeve), EW (agent applied over two layers of a standard elastic bandage), and CO (agent applied directly to the body). Participants were randomly assigned to either the GR or IC group and the order of barrier conditions was also randomized. Each subject completed three treatment sessions over a three-

day period. Surface skin temperature was assessed using a thermistor (409B, Measurement Specialties Inc., Dayton, OH) and digital monitor (Model 401, Yellow Springs Instruments, Yellow Springs, OH). Readings were conducted every 2.5 minutes over a thirty-minute application period and for thirty-minutes post-application. **Main Outcome Measures**: Dependent variable: skin temperature (°C). A three-way mixed factor [2 (group) x 3 (condition) x 25 (time)] repeated measures ANOVA was used to assess differences between treatment groups. The level was set a priori at .05 and interactions were analyzed using Tukey HSD test. **Results**: An interaction was found between cryotherapy agents for CO and EW barriers at various time periods ($F=2.208$, $P < .001$). After twenty minutes of application, IC resulted in lower temperatures than GR in the CO (9.40 ±4.5 °C and 13.61 ±2.7 °C, respectively) and EW (17.80 ±2.7 °C and 21.25 ±2.3 °C, respectively) conditions. Temperatures in the TS condition were not different between IC and GR (16.47 ±4.9 °C and 17.72 ±3.1 °C, respectively, $P = .71$). **Conclusions**: Game Ready™ and standard ice packs are effective cryotherapy agents in attaining therapeutic superficial tissue temperatures when applied without a barrier. The utilization of a dry barrier with cold modalities remains unwarranted, as they appear to hinder the abstraction of heat thereby not attaining the temperature decrease needed to reduce nociceptive fiber conduction.

Cold Perception, Surface, Subcutaneous and Intramuscular Temperatures Produced by Gebauer Pain Ease® Topical Vapocoolant Spray

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Context: Vapocoolant spraysrapidly cool the skin, providing brief local anesthesia for injections and intravenous cannulation as well as management of minor sports injuries and spray & stretch. Temperature effects in humans and effects of commonly used nozzle types, spray distances or spray durations have never been previously reported. **Objective**: To describe cold perception and temperature effects of Pain-Ease®.**Design**:crossover design. **Setting**: research laboratory **Patients or Other Participants**:convenience sample of 10 healthy participants (age =22.3±1.9yrs).**Interventions**:PainEase® was applied to the proximal forearm under 8 experimental conditions on different days at least 48 hrs apart. Conditions were determined using a 2x2x2 repeated measures factorial based on clinical use instructions. Independent variables were: nozzle type (mist & stream), spray duration (4 & 10 seconds) and spray distance (7.6cm [3 in]&12.7cm [5 in]). Order of testing was determined using a balanced Latin Square. **Main Outcome Measures**: Ambient and interface temperature were measured using surface thermocouples. Subcutaneous and 1cm intramuscular temperature were measured using sterile implantable thermocouples inserted via cannulae.Temperatures were recorded at 1 sec intervals for 500 sec.Cold severity perception was measured via 10cm Visual Analog Scale.Data were analyzed via repeated measures MANOVA with Sidak adjusted pairwise comparisons with $\alpha=0.05$. **Results**: Ambient (25.9± 0.4°C, p=0.79) and baseline temperatures (surface 31.1±0.4°C, SubQ 34.0±0.4°C, IM 34.5±.4°C, p=0.68) did not differ across conditions. Interface tempera-ture fell to -11.4±1.1°C and re-warmedwithin 4-5 minutes. SubQ temperaturefell to 28.1±1.0°C. IM temperature fell to 33.1±0.5°C. A main effect was observed for spray duration on cold perception (4sec = 3.9/10, 10 sec = 5.9/10, p<0.001) and on lowest temperature at all 3 depths (surface 4sec = -9.4± 0.7°C, 10sec = 13.4 ±0.4°C, p=0.001; SubQ 4sec = 30.5±.6°C, 10sec = 25.7± 0.5°C ,p<0.001; IM 4sec = 33.5±.3°C, 10 sec = 32.7±.3°C , p= 0.05). A main effect for nozzle was observed on cold perception (stream = 4.1/10, mist = 5.7/10, p=0.003) and on lowest temperature at only surface (stream = -7.5±0.6°C, mist = -15.4± 0.7°C, p<0.001) and SubQ depths (stream = 29.3±0.5°C, mist = 26.9± 0.6°C,p =0.03). All 3 subjects receiving mist nozzle/5in/10sec had adverse skin reactions consistent with mild frostbite and the condition was terminated. Temperature for it were -17.9±1.4°C.**Conclusions**: Pain Ease® cools skin to well below freezing re-gardless of application technique. This does not produce skin injury except in a single condition (mist, 5in, 10sec). Temperature changes at SubQ (~-5.9°C) and IM (~ -1.4°C) are small, short lived and may not be clinically meaningful. Mist nozzle produces much colder temperaturesand feels colder regardless of spray distance or duration. Spraying for 10sec feels colder and is colder than 4sec. Spraying for 10 seconds with the mist nozzle should not be used clinically.

Cold Perception, Surface, Subcutaneous and Intramuscular Temperatures Produced by Gebauer Ethyl Chloride Topical Vapocoolant Spray

Martin KM, Merrick MA: The Ohio State University, Columbus, OH

Context: Vapocoolant sprays rapidly cool the skin, providing brief local anesthesia for injections and intravenous cannulation as well as management of minor sports injuries and spray & stretch. Temperature effects in humans and effects of commonly used nozzle types, spray distances or spray durations have never been previously reported.**Objective**: To describe cold perception and temperature effects of Ethyl Chloride. **Design**:crossover design **Setting**: research laboratory **Patients or Other Participants**: convenience sample of 10 healthy participants (age=21.9±2.4 yr).**Interventions**: Ethyl Chloride was applied to the proximal forearm in 8 experimental conditions on different days with at least 48 hrs between. Conditions were determined using a 2x2x2 repeated measures factorial based on clinical use instructions. Independent variables were: nozzle type (mist & stream), spray duration (4 & 10 sec [or until skin blanching]) and spray distance (7.6cm [3 in]&17.8cm [7 in]). Treatment order was determined using a balanced Latin Square. **Main Outcome Measures**: Ambient and interface temperature were measured using surface thermocouples. Subcutaneous and 1cm intramuscular temperature were measured using sterile implantable thermocouples inserted via cannulae. Temperatures were recorded at 1 sec intervals for 500 sec.Cold severity perception was measured via 10cm Visual Analog Scale. Data were analyzed via repeated measures MANOVA with Sidak adjusted pairwise comparisons with ˜=0.05.**Results**: Ambient (25.5 ±0.5°C, p=0.52) and baseline temperatures (surface 30.3±1.18°C, SubQ 33.3±0.9°C, IM 33.5±.1.1°C, p=0.68) did not differ across conditions. Averaged across conditions, interface temperature was -8.9±1.3°C, SubQ temperature was30.7±1.1°C and IM temperature was 32.3±0.6°C. For interface temperature, a nozzleX distance X duration interaction effectoccured (p=0.007). Pairwise comparisons showed(mist,7in,4sec) did not produce interface temperatures below freezing (3.05±1.6°C) and was warmer than other conditions (ranged -6.27°C to -14.00°C). A main effect for nozzle (p=0.004) showed that stream (-10.94±0.9°C) was colder than mist (-6.89±0.6°C). A main effect for distance (p=0.007) showed that 3 in (-10.55± 0.7°C) colder than 7 in (-7.27±0.7°C). A main effect for duration (p<0.001) showed 4 sec (-6.65±0.9°C) was warmer than spraying until skin blanched (-11.18 ±0.5°C). Subcutaneously, a single main effect for spray duration (p=0.037) showed 4 sec (31.37± 0.4°C) was warmer than spraying until the skin blanched (30.12±0.7°C). No effect was observed intramuscularly (p=.912).For cold perception, a main effect for distance (p= 0.015)showed3 in (4.9/10±0.3) feels colder than 7 in (3.75/10±0.5). A main effect for duration (p<0.001) showedspraying until the skin blanched (5.34/10±0.4) feels colder than 4 sec (3.3/10 ±0.4).**Conclusions**: Other than (mist,7in,4sec), Ethyl Chloride cools skin to well below freezing without causing skin injury. Temperature changes at SubQ (~-2.8°C) and IM (~-1.1°C) are small, short lived and may not be clinically meaningful.

Surface Temperature, Sensation of Pressure, and Hamstring Flexibility are not Influenced by Counterirritants

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Context: Many health care professionals incorporate the use of topical counterirritants for pain relief. It is hypothesized that counterirritants numb the skin and increase tissue temperature, thereby increasing tissue extensibility. **Objective:**The purpose of the study was to determine if a counterirritant influencedsurface temperature, sensation of pressure (i.e. numbness), or hamstring flexibility. **Design:**Descriptive laboratory study. **Setting:** Applied Musculoskeletal and Human Physiology Laboratory. **Participants:** Thirty college aged individuals(age=21.17±3.84, ht= 169.16 ±10.26cm, mass= 73.06± 16.52kg) with no lower extremity injuries in the last 6 months and less than 90° of hamstring flexibility were recruited. **Interventions:** A 2x3x3 double-blind repeated measure design guided data collection. The independent variables were treatment (3cc of a counterirritant (Flexall 454®), a placebo (lotion with peppermint oil), and nothing (control)), time (pre- & post-treatment), and day (1st, 2nd, & 3rd). Subjects were randomly assigned to a treatment order prior to lying supine on a plinth with their hips and non-dominant leg secured with straps. Subjects then received surface temperature and sensation of pressure measures followed by hip flexion range of motion (ROM) measures. Surface temperature was taken with a surface copper-constant thermocouple secured with surgical tape at the center point between the gluteal crease and popliteal fossa. Sensation of pressure was obtained using Simmons-Winstein monofilaments. Monofilaments were applied directly to the skin until it bent and held for

approximately 1.5 seconds. We measured hip flexion ROM by applying a bubble inclinometer to the subject'sthigh based on the baseline Bubble Inclinometer Measurement Chart. Following all baseline data, we applied 1 of the 3 treatments before aseries of 3 30-second hamstring stretches. Immediately following the 3rd stretch,we performed all posttreatment measures. **Main Outcome Measures:**The dependent variables were surface temperature, sensation of pressure, and hip flexion ROM measured before and after each treatment on each day.**Results:**Range of motion increased between pretreatment and posttreatment ($F_{1,21}$=104.03; *P*=.001). Application of the counterirritant did not influence ROM ($F_{2,21}$=0.09; *P*=.9), surface temperature ($F_{2,21}$=0.56; *P*=.58) or sensation of pressure ($F_{2,21}$=0.29; *P*=.75). There was no difference in surface temperature or sensation of pressure between pretreatment and posttreatment times or days (both; Tukey-Kramer *P*> .05).**Conclusions:**Three cc of a counterirritant (Flexall454®) does not influence surface temperature,sensation of pressure, or hip flexion ROM immediately following a series of three 30 second stretches to the hamstring muscle group in individuals who have less than 90° of hamstring flexibility.

Relative Transmission of Coupling Media and Medications Commonly Used in Phonophoresis

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Context: Phonophoresis is commonly utilized in sports medicine and uses therapeutic ultrasound (US) to improve transdermal absorption of topically applied agents. Previous reports of treatment success have been inconsistent, creating a need to investigate the methods used with phonophoresis. Some topical agents may reduce or block US energy, therefore reducing ability of US to reach the tissues. **Objective:** To determine the relative acoustic transmission allowed by various agents at 1MHz and 3MHz frequencies. **Design**: Descriptive. **Setting**: Laboratory. **Patients or Other Participants:** There were no human participants in this study. Separate topical agents (gel-based n=6, cream-based n=7) were tested. **Intervention(s)**: A thickness of 1 mm of each preparation was placed in an individual plastic Petri dish that was placed over a transducer surface connected to an acrylic holder for an Ohmic US power meter. Continuous US was administered through each preparation at 1.2 W/cm^2 at both 1MHz and 3MHz frequencies for 30 seconds. **Main Outcome Measures**: Percent of transmission of US energy relative to commercial US gel was the dependent variable. Planned observational comparisons were made at both 1MHz and 3MHz frequencies. An arbitrary cutoff of greater than or less than 70% was used to determine effectiveness of the coupling medium as a transmitter of US energy. Mediums with relative transmission greater than 70% were considered good mediums for phonophoresis, while those with transmission less than 70% were considered poor mediums. Any value over 100% represented higher US transmission compared to commercial gel. **Results:** Inferential statistics assume that a sample is randomly selected from a population, but our samples were chosen based on common use by athletic trainers, not random selection. Instead, descriptive comparisons of transmission through topical preparations were made. Coefficients of variation (CV) were calculated to quantify stability of measures. CV ranges for 1MHz (0.00-0.09) and 3MHz (0.00-0.05) indicated very stable measurements. Gel-based agents tested at 1MHz and 3MHz were: Arnica gel=97% and 110%, Biofreeze =60% and 79%, Capzasin=70% and 93%, Cobroxin=76% and 91%, and Solarcaine=70% and 101%. Cream-based agents at 1MHz and 3MHz were: Arnica cream=67% and 74%, Australian Dream=54% and 80%, Bengay=37% and 55%, MediPeds Footcare=126 and 101%, Neuragen PN=76% and 90%, Octogen=38% and 47%, and Thera-Gesic=52% and 73%. **Conclusions**: Topical agents suspended in aqueous gels were generally effective in transmitting ultrasound energy, while many cream based agents were less effective, particularly at 1 MHz frequency. Many agents that are commonly used to provide a sensory effect, such as topical analgesics and counter-irritants in cream form, may block US transmission. Agents that reduce US transmission may lead to little treatment effect of phonophoresis to the patient and potential damage to the US equipment. We recommend that clinicians use gel-based agents at 3 MHz frequency for best US transmission.

Near-infrared Light Therapy Attenuates Strength Loss following Eccentric Exercise of the Biceps Brachii

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Context: Near-infrared (NIR) light therapy is purported to act as an ergogenic aid in delaying the onset and extent of muscle fatigue during exercise. Attenuating the onset and extent of muscle fatigue would be beneficial during rehabilitation when impaired muscle function is one of the greatest limitations to recovery. However, no studies have quantified fatigue responses to NIR light therapy. **Objective:** The primary objective of this investigation was to evaluate the ergogenic effect of NIR light therapy on skeletal muscle function. **Design:** Cross-over, repeated measures, sham controlled design. Each subject received each treatment dose in random order followed by an exercise induced fatigue protocol for the biceps brachii muscle. **Setting:** Controlled laboratory setting. **Participants:**

Thirty-nine subjects, comprised of healthy men (n=21) and women (n=18) aged 18-35 years (Avg. age = 20.0 ± 0.164, Avg. height = 1.691 m ± 0.018, Avg. weight= 68.414 kg ± 1.824, Avg. BMI = 23.804 ± 0.368) with no current history of injury to the upper extremity. **Interventions:** A class 4 laser that emitted NIR light was used to treat the biceps brachii muscle. Each participant received both an active and a sham laser treatment in random order. Active laser was administered to the biceps for 4 minutes with a cumulative dose of 360 Joules.Sham laser treatment was identical to the active treatment except no power was emitted from the laser diode.Subjects then underwent a fatigue protocol on an isokinetic dynamometer. Each subject performed 3 sets of 20 concentric (45 deg/s) and eccentric (60 deg/s) contractions using the biceps brachii muscle. **Main Outcome Measures:** The dependent variables were strength loss or fatigue index, number of repetitions to fatigue, and pain reporting. Strength loss indices were calculated by dividing the post-exercise isometric strength value (Nm) with the pre-exercise value multiplied by 100.ANOVA with repeated measures were used to analyze changes in these measures between treatments at pre-exercise and immediately at post-exercise. **Results:** Strength loss index for the active laser (0.56 ± 0.13) treatmentwas significantly less compared to the sham laser (0.61± 0.12) treatment [$F_{(1,38)} = 4.07, p= 0.05$]. **Conclusions:** Subjects receiving the active laser treatment were able to resist fatigue at a greater extent than when they received the sham laser treatment. Our findings implicate NIR light therapy as an effective ergogenic aid capable of attenuating strength loss and resisting muscle fatigue during resistance exercise.

Forearm Rotational Motion Adaptations among Baseball Pitchers and Position Players

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Context: Due to the repetitive nature of the baseball throwing motion, many chronic adaptations have been identified in the throwing shoulder of baseball players. However, little research has investigated what adaptations may occur in forearm rotation among and between baseball pitchers and position players. **Objective:** To determine the within-group and between-group range of motion (ROM) differences in forearm pronation, supination, and total arc of motion in a group of baseball pitchers and a group of position players. **Design:** Cross-sectional. **Setting:** Athletic training room. **Participants:** Fifty professional baseball pitchers (age=22.1±2.2years, height= 188.5 ±5.7 cm, mass=87.4±8.7 kg) and 43 position players (age=22.9±4.7 years, height =183.8±5.1 cm, mass= 86.7 ±7.2 kg) volunteered to participate. All participants had no recent history (past 2 years) of upper extremity pathology or any previous surgery. **Inter-ventions:** We measured bilateral elbow pronation, supination, and total arc of motion using a digital inclinometer. We used 2-tailed *t* tests with a Bonferroni correction ($p<.004$) to determine if any differences existed between and within the pitchers and position players. **Main Outcome Measures:** Dependent variables included forearm pronation ROM, supination ROM, and total arc of motion. **Results:** Pronation, supination, and total arc of motion for the dominant and non-dominant arms of the pitchers were 72.5°±8.1°, 82.5°±6.5°, 154.9°±11.4° and 76.4°± 7.7°, 82.6°±5.5°, 159.0°±10.9°, respectively. Pronation, supination, and total arc of motion for the dominant and non-dominant arms of the position players were 70.3°±8.0°, 81.6°±7.2°, 152.0°±9.8° and 72.6° ±5.6°, 81.4°±6.1°, 154.0°±7.6°, respectively. There were no significant differences between the pitchers and position players for either forearm pronation ($p>.01$), supination ($p>.30$), or total arc of motion ($p>.01$). However, the pit-chers did have significantly less pronation ROM ($p=.001$, effect size=.48) and total arc of motion ($p=.001$, effect size=.36) in their throwing elbow compared to their non-throwing elbow. There was no signi-ficant difference bilaterally for supination ($p=.88$) among the pitchers. The position players had a significant difference in their bilateral total arc of motion ($p=.001$, effect size=.20), but no differences in pronation ($p=.07$) or supination ($p=.82$). **Conclusions:** The significantly less amount of forearm pronation in the throwing arm of pitchers may occur due to the large eccentric forces produced by the supinator muscles as the elbow pronates during the follow-through and deceleration phases of the throwing motion. The accumulation of these eccentric forces may result in shortened supinator muscle length and a subsequent decrease in pronation ROM. Although both pitchers and position players had a statistically significant decrease in total arc of motion in the throwing elbow compared to the non-throwing elbow, the small effect sizes indicate these differences may not be clinically significant. These forearm ROM adaptations should to be taken into consideration in the prevention, evaluation, and treatment of elbow injuries among baseball players.

Recovery of Upper-extremity Joint Position Sense Acuity in Softball Athletes After a Functional Fatigue Protocol

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Context: Research suggests that fatigue hampers upper-extremity joint position sense in baseball players. This insight helps guide injury prevention and rehabilitation protocols. However, little evidence has examined such effects in softball athletes. **Objective:** To evaluate the effects of functional fatigue and the rate of recovery of upper-extremity position reproduction in softball athletes. **Design:** We used a repeated measures design to compare prefatigue position reproduction acuity with measures taken after a throwing fatigue protocol (0, 4, 7, and 10 minutes). **Setting:** Controlled, labo-ratory. **Participants:** 15 healthy female collegiate softball athletes (age, 19.1±1.2 years; height, 167.8±8.2 cm; mass, 65.2±7.3 kg) volunteered. **Inter-ventions:** During the fatigue protocol, athletes assumed a single-knee stance and threw at a target every 5 seconds with maximum velocity. Subjects rated their perceived exertion after every 20 throws using BORG's scale. We considered athletes fatigued when they reported an exertion level above 14. **Main Outcome Measures:** Using an electromagnetic tracking system, we recorded position of the thorax and dominant-side hand, forearm, humerus, and scapula. Dependent variables included 3-dimensional variable error (3DVE) of the scapulothoracic, glenohumeral, elbow and wrist joints and end point (hand-to-thorax position) measured during reproduction of two arm positions (arm-cock, ball-release). Blindfolded subjects assumed a single-knee stance during position

reproduction tests. Measures were taken prefatigue, immediately postfatigue (PF-1), and 4 (PF-2), 7(PF -3) and 10 (PF-4) minutes after fatigue. To observe differences over time, we used Friedman's test (α=*P<0.05)*. Where differences were significant, a post hoc Dunn's test compared prefatigue to each postfatigue 3DVE measure, *P<0.05*. **Results**: Friedman's test revealed a significant change in acuity for each joint and end point position at arm-cock and ball-release (*P*<0.001) except wrist acuity at ball-release (*P=0.07)*. For the arm-cock position, Dunn's test revealed significant increases in 3DVE from prefatigue to PF-1 for scapulothoracic (5±2° to 12±5°), glenohumeral (8±3° to 19±4°), elbow (23±4° to 33±9°), wrist (16±5° to 20±6°) and endpoint (9±6mm to 20±12mm). Scapulo-throacic (9±3°) and wrist (19±5°) acuity remained significantly affected at PF-2. Glenohumeral acuity (17±6°) remained diminished at PF-3, before recovering at PF-4. Analysis of acuity at the ball-release position indicated significant differences between prefatigue and PF-1 for scapulo-thoracic (12±3° to17± 5°), gleno-humeral (21±6° to 29±9°), elbow (28±7 to 36±8°), wrist (17±3 to 22±7°) and endpoint (24±11 to 45±13mm) 3DVE. Recovery of elbow 3DVE was evident only after PF-2 (32±8°). **Conclusions:** After 4 to 7 minutes of recovery, position reproduction acuity for both arm positions recovered in each joint and overall endpoint position. Position reproduction deficits following fatigue in collegiate baseball athletes have been previously reported. Our results suggest that acuity in collegiate softball athletes recovers in a similar timeframe. These data suggest that neuromuscular recovery requires 4 to 7 minutes after a fatiguing bout of throwing.

A Comparison of Scapular Upward Rotation betweenOverhead Athletes, Non-Overhead Athletes and Non-Athletes

Tucker WS, Ingram RL, Shimozawa Y: University of Central Arkansas, Conway, AR; Georgia Southern University, Statesboro, GA; A.T. Still University, Mesa, AZ

Context: Lack of adequate scapular upward rotation has been associated with chronic shoulder injuries. Previous research on healthy overhead athletesfound differences in scapular upward rotation between baseball pitchers and position players, and differences in the dominant arm verses the non-dominant arm. It is unclear if scapular upward rotation differences exist between healthy overhead athletes, non-overhead athletes and non-athletes. **Objective:** To assess scapular upward rotation differences between healthy male overhead athletes, non-overhead athletes and non-athletes.**Design:** One-between (group) comparison.**Setting:** Controlled laboratory environment. **Patients or Other Participants:**Thirty-nine males with no history of shoulder injury participated in this study: 13 intercollegiate overhead athletes (19.8±1.4 y, 181.8±6.6 cm, 88.4±8.4 kg), 13 intercollegiate non-overhead athletes (20.8±1.3 y, 178.9±5.9 cm, 83.4±15.6 kg) and 13 recreationally fit non-athletes (21.8±0.8 y, 178.9±6.8 cm, 89.1±11.4 kg). **Interventions:** Static scapular upward rotation was measured on the throwing dominant arm with a digital protractor while subjects were at rest and at 60°, 90° and 120° 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 upward rotation measurements at each position were averaged. The independent variable was group (overhead, non-overhead and non-athlete). **Main Outcome Measures:**The dependent variables were the mean upward rotation at the four positions of humeral elevation (rest, 60°, 90° and 120°). For each dependent variable, the influence of group on the mean upward rotation was compared using a one-way ANOVA. The alpha level was set at *p*<0.05. **Results:** The analysis revealed statistical differences at rest ($F_{2,38}$=7.750; p=0.002), 60° ($F_{2,38}$= 6.408; p=0.004), 90° ($F_{2,38}$=17.055; p<0.001) and 120° ($F_{2,38}$=14.689; p<0.001).A Scheffe's post hoc analysis revealed at restupward rotation for the overhead group (1.7±4.9°) was significantly greater compared to the non-athlete group (-5.9±5.4°). At 60°, upward rotation for the overhead (5.5±5.1°) and non-overhead groups (6.6±5.1°) were significantly greater compared to the non-athlete group (-0.6±6.4°). At 90°, the overhead(21.5±4.3°) and non-overhead groups(23.4±5.1°)were significantly greater compared to the non-athlete group (12.3±5.9°). At 120°, the overhead(38.0±2.8°) and non-overhead groups(40.4±6.1°)were significantly greater compared to the non-athlete group (31.1±4.2°). **Conclusions:** The overhead and non-overhead groups demonstrated greater scapular upward rotation at 60°, 90° and 120° of humeral elevation when compared to the non-athlete group.Regular upper body resistance training performed by the overhead and non-overhead athletes may have resulted in increased force production by the serratus anterior, upper trapezius and lower trapezius. In addition to injury status,scapular upward rotation may be influenced by physical activity. Establishing generalized standard ranges of motionfor scapular upward rotation may not be possible. Routine assessment is recommended to identify abnormalities or changes in scapular upward rotation.

Shoulder Stiffness Adaptations in Division I Collegiate Baseball Players

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Context: During the deceleration phase of the overhead throw, energy absorption must be distributed across musculotendinous and capsulo-ligamentous tissue within a limited range of motion, to minimize the likelihood of injurious stress. This is largely accomplished through exquisite neuromuscular control, which regulates glenohumeral (GH) stiffness characteristics. While the posterior rotator cuff and scapular stabilizing muscles can stiffen to optimize dynamic restraint, thickening of the posterior capsule may also be critical to static restraint. **Objective:** To compare active and short range GH stiffness and examine its correlation to posterior capsule thickness (PCT). **Design:** A single group post test only. **Setting:** This study was performed in a controlled laboratory setting. **Patients or Other Participants:** Twenty-three division one collegiate baseball players (age = 19.5± 1.4 years, mass = 89.2± 5.9 kg, height = 186.6± 4.0 cm) with no current injury or surgery in the past eight months. **Interventions:** Independent variables were arm (dominant and non-dominant). Active and short range GH stiffness was measured by a customized Stiffness and Proprioception Assessment Device (SPAD). Stiffness was defined as the change in torque over the change in position. Active stiffness was measured from the start of internal rotation (IR) to the point of peak torque. Short range stiffness was measured from the start of IR to 3° of motion. PCT was measured with an ultrasound system (Sonosite Titan, Sonosite Inc., Bothell, WA). Paired sample t-tests were performed for active and short range GH stiffness. Pearson product moment correlation coefficients assessed the relationships between GH stiffness and PCT. **Main Outcome Measures:** GH stiffness was measured with the subject lying prone. The shoulder and elbow were positioned in the 90°/90° position with 0° of external rotation (ER). Subjects were asked to maintain an isometric ER contraction of 50% MVIC. The SPAD then rotated their arm 20° into IR. PCT was measured from an upright seated position with the shoulder in 0° abduction and neutral rotation. **Results:** The dominant arm (DA) had significantly greater active and short range GH stiffness compared to the non-dominant arm (NDA) (DA=1.65 ±0.17Nm/°, NDA =1.56± 0.10Nm/°, p=0.008; DA= 2.09± 0.52Nm/°, NDA= 1.93± 0.39Nm/°, p=0.041) respectively. Active GH stiffness was significantly correlated with PCT (0.297, p=0.047), however short range GH stiffness was not significantly correlated with PCT (0.114, p=0.452). **Conclusions:** Healthy collegiate baseball players present with adaptations of their stiffness regulation strategies. There were also correlations between stiffness and morphologic changes. Our results support the theory that PCT has an impact on the energy absorption capabilities of the shoulder during the deceleration phase of throwing. It also seems that tightening of the series elastic component within the posterior rotator cuff may be causing the increase in short range stiffness on the dominant arm.

Relationship Between Dynamic Acromiohumeral Interval and Scapulohumeral Rhythm in Overhead Athletes Between 0 and 60

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Context: Previous research has linked alterations in scapulohumeral rhythm (SHR) with shoulder injuries and subacromial impingement. Previous in-vivo investigations of SHR and acromiohumeral interval (AHI) are limited and may not accurately represent dynamic shoulder kinematics. **Objective:** To determine if SHR between 0° - 30° and 30° - 60° are related to AHI in overhead athletes during dynamic scaption. **Design:** Descriptive cohort study design. **Setting:** Athletic training facility. **Participants:** Fortyfive male and female, collegiate overhead athletes (age = 19.6±0.8 years, mass = 77.0± 11.6 kg, height = 1.72±.08 m) with no history of surgery or current injury involving their dominant arm. **Interventions:** Participants performed three trials each of an unloaded and loaded scaption exercise from 0°-90° while seated. Amount of load during the weighted scaption exercise was normalized based on anthropometric data for each participant. True anterior-posterior fluoroscopic images of the glenohumeral joint were captured in real time video during the second trial of each condition. Video was captured at 30 frames per second with a 1000x1000 pixel resolution, transferred via a digital video recording device to a personal computer and analyzed using OsiriX software. Pearson correlations were calculated for SHR 0°- 30° and AHI at 30° and for SHR 30°- 60° and AHI at 60° during loaded and unloaded scaption. **Main Outcome Measures:** AHI was measured as the smallest vertical distance between the inferior acromion and superior humeral head. AHI values were recorded at two humeralthoracic elevation positions

(30° and 60°). Scapular upward rotation was determined using differences in glenoid inclination angles, the angle between a vertical line and the inferior and superior glenoid tubercle. SHR was calculated as the amount of humeral-thoracic elevation relative to scapular upward rotation within the selected range. One investigator (MT) performed all measurements. **Results:** SHR 0° - 30° was 9.17±12.1 (unloaded) and 4.40±4.4 (loaded). AHI at 30° was 6.9±2.2 mm (unloaded) and 6.78±2.3 mm (loaded). SHR 30° - 60° was 6.17±11.8 (unloaded) and 8.58±4.2 (loaded). AHI at 60° was 4.40±1.6 mm (unloaded) and 3.67±1.3 mm (loaded). Poor, non-significant associations were observed at 30° unloaded (R = -.105, p=.491), 30° loaded (R = .157, p=.308) and 60° loaded (R = -.102, p=.505). A fair, significant association was observed at 60° unloaded (R=.341,p=.022) **Conclusions:** SHR and AHI do not appear related during dynamic motion between 0° and 60° in healthy, overhead athletes. The significant association between SHR 30°-60° and AHI during unloaded scaption at 60° only accounts for 12% of the variance. Large SHR variability was observed which might make statistical and clinical applications difficult.

Shoulder EBF

Wednesday, June 27, 2012, 12:15PM-1:15PM, Room 275; Moderator: Paul Borsa, PhD, ATC

Injury and Illness Epidemiology at a University-Based Summer Sports Camp Program

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Context: While numerous epidemiology studies have been conducted at the high school and collegiate levels, there is a dearth of similar information available to guide the delivery of sports medicine services provided at summer sports camps. Given the popularity of participation at such camps and the frequency with which ATs are hired to provide medical coverage, injury and illness information can prove to be invaluable. **Objective:** This novel study aims to describe the injury and illness experience of youth sports camp participants at a university-based summer sports camp program over a 4-year period. **Design:** Descriptive epidemiology study. **Setting:** The study was conducted at a large university which houses approximately 80 camps for 22 sports over a 12 week period each summer. ATs and ATSs are hired in the capacity of sports heath technicians and sports heath aides, respectively. They are responsible for documenting all AT/ATS-participant contacts, per job description. A contact is defined as a single event in which an AT/ATS and camp participant interact for medical attention, e.g. injury assessment, delivery of treatment. **Patients or Other Participants:** Male and female athletes ages 10 through 17 years participating at a university-based summer sports camp program served as the target population. Enrollment for 2008 through 2011 was 43,852 camp participants. Per camp injury/illness logs, any case documenting at least one variable of interest was included, totaling 11,826 cases. Cases for pre-existing conditions were excluded. **Data Collection and Analysis:** Data from cases were applied to the National Athletic Injury/Illness Reporting System case report form, and coded accordingly. Frequency counts were conducted for independent variables (sport, gender) and dependent variables (body part, injury/illness type, treatment). Camp enrollment was utilized to calculate the rates of contacts and injury/illness. Chi-square tests were calculated to determine statistical significance of observed frequencies by sport and by gender. $P < 0.05$ indicated statistical significance. **Results:** Preliminary data demonstrate an AT/ATS-participant contact rate of 27.05/100 camp participants and injury/illness rate of 11.09/100 camp participants. Golf represented the lowest injury/illness rate, 0.21/100 camp participants, while rugby represented the highest, 71.96/100 camp participants. Lower extremity injuries comprised the majority injuries by body part for male (45.2%) and females (47.8%). Males participating in basketball or soccer were more likely to sustain joint injuries (68.6% and 70.8%, respectively), while males participating in football were more likely to sustain musculotendinous injuries (53.9%), a statistically significant finding ($p < 0.001$). **Conclusions:** Injury/illness rate, type, and location vary by camp participant gender and sport. The differences observed among the variables of interest demonstrate potential differences in the medical needs of camp participants. The data can be utilized to provide a practical reference to make clinical decisions, such as determining staffing needs or injury-preventions strategies to employ.

Orthopedic Injuries Sustained in an Athletic Environment Classified as Trauma at a Pediatric Hospital from 2004 to 2010

Rogers KJ, Hochstuhl D, Elwell S, O'Brien K, Shah SA: Alfred I duPont Hospital for Children, Wilmington, DE

Context: The rationale for the study was to document orthopedic trauma related athletic injuries that occurred through a pediatric emergency department (ED) over a seven year period. **Objective:** To review distribution of sports and type of orthopedic trauma with subsequent care. **Design:** Retro-spective review of medical charts. **Setting:** Pediatric hospital. **Patients or Other Participants:** Patients between the ages of 1 – 19 years of age from 2004 to 2010. **Interventions:** All E codes were searched. All Orthopedic injury diagnosises were included. No person was excluded based on age, gender, or race. **Main Outcome Measures:** The outcome measures were the trauma E codes, sex, age, location of injury, prior history, mechanism of injury, trauma classification, sport, orthopedic injury and joint, medical injury and area, diagnosis number, and surgery. Frequency and descriptive statistics were calculated using SPSS 17 (SPSS Inc., Chicago, IL). **Results:** Five hundred and forty one patients were identified as having an injury related to sports; 429 were male, and 112 were female and average age was 13 years. Intake status was: (1) admitted (265); (2) transferred and admitted (240); (3) transferred (36); and (4) death (0). Number of previous facilities was: 0 (259), 1 (277), and 2 (5). Two highest E-codes were fall from collision in sport (231) and struck accidentally in sport (118). The most common mechanism of injury (MOI) was player to player contact (254). The balance of MOIs were contact with playing surface (193),

contact with playing apparatus (61), and no contact (22). Four highest locations were: football field (97); soccer field (37), home (38), and street (35). Thirty-five people had a prior history of the same injury. Thirty-two different sports were implicated in injuries seen in the ED - the most common were: football (155), soccer (64), and basketball (56). The occurrences of orthopedic and non-orthopedic injuries were 479 and 116 respectively. Sixty patients had both an orthopedic and medical injury. Elbow (71) and forearm (70) fractures were the most frequent orthopedic injuries. The most common non-orthopedic injuries were concussions (60) and spleen laceration (16). One Hundred and two patients had multiple injuries: 2 (72), 3 (16), 4 (19), 5 (2), 6 (2), and 8 (1). Surgical intervention occurred in 58% of the cases. **Conclusions:** This study has updated a previous study for pediatric athletic injury trauma frequency and related treatment for both orthopedic and medical injuries. This study demonstrated that patients may experience multiple injuries (102 patients) and orthopedic and medical injury simultaneously (60). This study may lead to further understanding of the prevalence of traumatic athletic injury in this population with subsequent prevention strategies.

Factors Related to the Disparity in Access to Athletic Training Services in South Carolina High School Athletics Programs

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Context: Employing athletic trainers(AT) has long been recommended as a solution for improving medical care in high school sports. Recent research suggests a disparity in the medical care provided by South Carolina(SC) schools based on access to AT services; however, no research has examined factors related to the existence of AT services in schools. **Objective:** To examine the relationship between the existence of AT services in high schools and factors suggested by literature to be related. ***Design:*** Cross-sectional study. **Setting:** Mailed/emailed survey. **Participants:** 63%(166/263) of SC high schools. **Intervention(s):** SC high schools were surveyed regarding existence of AT services and six factors suggested by literature to be related to AT services (independent variables): school size, setting, poverty, public/private status, proximity to medical facility, and budget for sports medicine supplies. After pilot-testing, data were collected via a systematic, modified-Dillman approach. Test-retest reliability was strong (r=.89). **Main Outcome Measure(s)**: Presence and source of AT services served as dependent variables. SPSS was used to calculate frequencies and chi-square analysis. **Results:** Chi-square analysis identified significant relationships between presence of an athletic trainer and school setting(X^2=16.28,P=.001), size(X^2=16.63,P=.002), and sports medicine supply budget(X^2= 38.49, P=.001). Significant relationships were also identified between the source of athletic training services and school size X^2 = 29.89,P<.001), setting (X^2= 20.32, P=.002), and sports medicine supply budget(X^2= 70.58,P<.001). No relation-ship was identified between presence or source of AT services and a school's rate of free/reduced lunch program qualifiers, proximity to medical facility, or public private status. *Frequency of AT's in Schools by Setting*: 97%(suburban), 89%(city), 74%(small towns), and 57%(country) reported an AT in their school. 57% of suburban schools had school-based AT's; 40% were clinic, hospital, university-based. 45% of city schools had school-based AT's; 44% were clinic, hospital ,university-based. 32% of small towns had school-based AT's; 42% were clinic, hospital,university-based. 17% of rural schools had school-based AT's; 40% were clinic,hospital,university-based. *Frequency of AT's in Schools by Size*: 95%(4A-largest), 86%(3A), 73%(2A), 62%(1A-smallest) reported an AT in their school. 4A(65% school-based; 30% clinic,hospital,university-based); 3A(36% school-based; 50% clinic,hospital,university-based); 2A(30% school-based; 43% clinic, hospital,university-based); 1A(15% school-based; 46% clinic, hospital, university-based). *Frequency of AT's in School's by Sports Medicine Supply Budget:* For schools with AT's, 16%($0-$1000), 45% ($1001-$3500), 25%($3501-$8000), 14% (>$8000). Schools with school-based AT's, 7%($0-$1000), 32% ($1001-$3500), 34%($3501-$8000), 27% (>$8000). For schools with a clinic, hospital, university-based AT 25%($0-$1000), 56%($1001-$3500), 18% ($3501-$8000), 0% (>$8000). For schools without an AT 68%($0-$1000), 24%($1001-$3500), 8% ($3501-$8000), and 0%(>$8000). **Conclusions:** In SC high school athletics school setting, size, and sports medicine supply budget were related to the presence and source of the AT services. These results provide guidance for decision-makers (school administrators and legislators) and those who influence decision-makers (parents and athletes) in identifying disparities in access to healthcare in high school sports and improving the medical care provided for inter-scholastic athletes.

Lower Extremity Injury Rates in Children and Adolescents: A Systematic Review

Tritsch AJ, Pye ML, Shultz SJ: University of North Carolina at Greensboro, Greensboro, NC

Context: Increased incidence of sport related injuries coincide with increased participation in sports. Yet, currently not clear is whether children are suffering different sport-related injuries than adults, and whether the types and location of injuries in children change throughout maturation. **Objective:** To examine lower extremity injury rates in children and adolescents, and determine if sport-related lower

extremity injury rates and types change during the adolescent years. **Data Sources:** PubMed and Web of Science databases were systematically searched for articles published between 1985 and 2010 using the search terms injury epidemiology, children OR youth OR adolescent, sport OR physical activity. **Study Selection:** Prospective, retrospective, and cross-sectional epidemiological studies were included if they reported and stratified lower extremity injury rate or percentage (two or more body parts) by age or maturation (two or more groups). Studies that reported injury rate but did not break results down by age or maturation were excluded. Also excluded were studies related to traumatic injury (such as car accidents), skiing or snowboarding, ice hockey/skating, and disease, as the mechanism and surface differences were outside of the scope of the current review. Thirteen studies that reported sport-related injury rates stratified by one or more age groups and that fell within the age range of 5-19 years were included. **Data Extraction:** Two reviewers independently assessed all possible studies for inclusion and evaluated study quality. Injury rate, injury type, body part, and age were extracted from tables, figures, and text of the included studies. A critical appraisal tool was used to assess methodological soundness of epidemiological studies, with the average score awarded being 20.2 out of 37 possible points (range: 14-27). **Data Synthesis:** Among the 13 included studies, inconsistencies in injury definitions, age stratification, injury rate definitions, and injury rate computations prevented us from performing a meta-analysis. The only consistent trend in injury type was found in population based studies, where there was an increased percentage of sprains/strains and a decrease in fractures with age. Sprains/strains represented 11.0-32.9% of all injuries in 5-11 years old and increased to 21.4-44.4% in 15-18 year olds (an increase of 11.5-17.7%). The most commonly injured body part was the ankle regardless of age group. The majority of severe injuries were sustained at the knee. **Conclusions:** Difficulties arise in comparing existing literature on injury occurrence in adolescence due to inconsistencies in the definition of injury, methods of computing injury rate, and breakdown of age groups across studies. This has resulted in calls for a worldwide adoption of a common injury reporting model to enhance our ability to compare injury risk and occurrence across sports and ages. Clinicians should remain cognizant of the increased occurrence of sprains/strains throughout childhood and adolescence.

Intra-rater and Inter-rater Reliability of the Five Image-Based Criteria of the Foot Posture Index-6

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Context: The Foot Posture Index-6 (FPI-6) is considered a simple quantification tool to assess static foot alignment. Direct patient contact is required for assessment of one of the six criteria that comprise the FPI-6; the remaining five criteria may be evaluated using still-frame photographs. While direct visual observation is typically performed for this assessment, it may not be necessary for a clinician to be physically present at the examination if the image-based criteria are utilized. This may allow clinicians to save assessment time, and multiple clinicians to evaluate large groups of patients quickly. Although both intra-and inter-rater reliability of the FPI-6 have been investigated, reliability using only these five image-based criteria has not been established. **Objective:** To establish the inter- and intra-rater reliability of 5 image-based criteria from the FPI-6. **Design:** Descriptive laboratory study. **Setting:** Research laboratory. **Participants:** Forty participants (23F, 17M; 23.67±8.49yrs; 64.59±14.43kg; 166.07±11.79cm) volunteered. **Interventions:** Participants main-tained a relaxed stance with double-limb support while an investigator took three photos of the posterior ankle, talonavicular joint, and medial longitudinal arch. **Main Outcomes:** Using the photographs, two investigators assessed the five image-based criteria of the FPI-6 for both feet of 40 participants on three occasions separated by a day. Each criterion was scored on a scale of -2 to +2, with a total FPI score ranging from +10 to -10. Each participant's foot was classified as highly pronated with a score of 10, pronated with scores of 6 to 9, normal with scores of 0 to 5, supinated with scores of -1 to -4, or highly supinated with scores of ≤-5. To assess inter-rater reliability, Intraclass Correlation Coefficients ($ICC_{3,k}$) with 95% confidence intervals (CI) were calculated for the average FPI scores for the three assessments for each investigator. Cohen's kappa coefficient was used to examine the amount of agreement for classification of foot posture between the two raters. The intra-rater reliability ($ICC_{3,k}$) of the average FPI scores for two raters for each posture assessment was determined. Significance was set *a priori* at $P < 0.05$. **Results:** The inter-rater reliability was moderate for both left ($ICC_{3,2}$=0.614,95%CI; 0.195, 0.807) and right feet ($ICC_{3,2}$ =0.576,95%CI;-0.065, 0.813). For the classification of foot posture based on raw scores, the amount of agreement between two raters was poor for both left (K=-0.186) and right (K=-0.099) feet. The intra-rater reliability was excellent for both left ($ICC_{3,2}$ =0.956,95%CI; 0.925, 0.975) and right feet ($ICC_{3,2}$=0.959, 95%CI; 0.931, 0.977). **Conclusions:** Excellent intra-rater and moderate inter-rater reliability was found using only the five image-based criteria of the FPI-6. However, the classification of foot posture did not improve the amount of agreement between raters. Therefore, caution is needed when interpreting FPI scores from five image-based criteria.

Normative Baseline Values for Balance Error Scoring System in Healthy Male and Female High School Athletes during 2010-2011

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Context: Assessment of postural stability is an important part of concussion evaluation and a comprehensive concussion management program (CMP). Baseline values for balance testing are an important piece of data when making return to participation (RTP) decisions, and may not always be available. Using age and gender-specific norms may be useful cases where no baseline data exist. Age-stratified normative values for the Balance Error Scoring System (BESS) forhigh school athletes have not been previously reported. **Objective**: To determine differencesin age and to provide normative values for BESS baseline scores in healthy high school athletes. **Design**: Retrospective cross-sectional study. **Setting:** Controlled environment free of external stimuli in 28participating high schools. Starting in 2010, baseline concussion testing was implemented by a statewide CMP led by a contingent of athletic trainers funded by the State of Hawaii Department of Health. **Partici-pants:**De-identified data from baseline BESS tests from school year 2010-2011 for 2,825[age=15.5±1.2 years old (y/o), females (F) n=979, males (M) n=1,846] high school athletes free of injury and not currently in a balance or postural stability training program. **Interventions:** Baseline BESS testing for all contact sport athletes was administered in a setting of 8 participants per group.

Baseline BESS scores were video recorded and scored by two athletic trainers(interrater reliability=.87) prior to the competitive season. **Main Outcome Measures:** Total error score on the BESS was compared using univariate analysis of variance on gender (M,F) andthree age groups (13-14y/o *n*=851, 15-16y/o *n*=1,526, and 17-18y/o *n*=448).Mean, standard deviation (SD), and 95% confidence intervals were reported. **Results**:No significant (F_1=.066, *p*=.798, power = .058) differences in baseline BESS scores were found between males (17.55±6.60, CI=17.26-17.93) and females (17.68±6.79, CI=17.02-18.01).Significantly(F_2=5.874, *p*=.003) higher baseline BESS scores were found for13-14y/o (18.19±6.60, CI=17.73-18.72) compared to15-16y/o (17.37±6.65, CI=17.04-17.74) and17-18y/o (17.22± 6.76, CI=16.34-17.71). **Conclusions**: In our substantial sample of high school athletes, we found no gender differences and that younger athletes (13-14y/o) committed more errors than older athletes. These findings support the recommendation that baseline BESS scores be obtained every two years during high school matriculation. Regardless of gender, for the majority of high school athletes in this sample, baselineBESS values were similar for older (15-18 y/o) high school athletes, indicating that the BESS was a robust balance test in this setting. In cases where no baseline exists, normative datamay help health care providers interpret anormal baseline range of BESS scores for high school athletes or when determining if baseline scores seem reasonably valid.

Landing Error Scoring System: Describing Sex Differences in a Traditional College Athletics Setting.

King CE, Valovich McLeod TC, Bay RC, Lam KC: A.T. Still University, Mesa, AZ

Context: The Landing Error Scoring System (LESS) is a standardized clinical tool used to assess movement patterns during a jump-landing task and to identify individuals who may be at risk for knee injuries. While the LESS has been used to assess landing patterns in military cadets and youth soccer players, little is known of its use in a traditional college athletics setting. **Objective:** To describe sex differences in landing movements in collegiate athletes using the LESS. **Design:** Cross-sectional. **Setting:** College athletic training facilities. **Patients or Other Participants:** A convenience sample of 101 female (age=19.1±1.1years, height= 167.6± 8.4 cm, mass=63.5 ±8.8 kg) and 116 male (age=19.4±1.5 years, height= 181.4±8.5 cm, mass=76.7 ±10.7 kg) athletes participating in ten intercollegiate sports. **Interventions:** Sex of participant was the independent variable. Participants performed three trials of a standardized jump-landing task that was videotaped from the frontal and sagittal views and later scored using the LESS. The LESS is a valid and reliable (interrater reliability=.84) 17-item scoring system that evaluates landing characteristics (eg, foot position, foot contact, stance width, ankle plantar flexion, knee flexion, knee valgus, trunk flexion) at two discrete time points (initial ground contact, maximum knee flexion) on a binary scale (error, no error). Each trial produces a total score and the mean of all total scores represents an overall score (OS), with higher scores indicating poorer landing patterns. OSs were classified into one of four previously reported landing pattern groups (LPG): excellent (≤4), good (>4 to ≤5), moderate (>5 to ≤6) and poor (>6). **Main Outcome Measures:** Dependent variables were the 17 LESS scoring items (SI), OS, and LPG. For sex comparisons, chi-square tests were used for each SI and for the LPG and an independent-samples t-test was used for the OS. Alpha was p<.05. **Results:** Females more frequently demonstrated a knee valgus angle at initial contact (female=60.0%, male=30.0%, x^2= 21.197, p<.001), knee valgus angle at maximum knee flexion (female =61.8%, male=46.6%, x^2=24.377, p<.001) and frontal plane movement during the jump-landing task (female=98.0%, male=88.9%, x^2_1= 7.134, p=.009) as compared to males. Females also demonstrated a higher OS than males (females=5.8±2.3, males=5.1±2.5, p=.04). Females and males did not differ significantly on LPG (x^2=4.766, p=.19): females (excellent=25.7%, good=15.8%, moderate=14.9%, poor=43.6%) and males (excellent=39.7%, good= 13.8%, moderate=12.1%, poor= 34.5%). **Conclusions:** Our results corroborate previous reports that females display more improper jump-landing movements than males, particularly on the frontal plane. Although there was a statistically significant difference in OS between sexes, the difference was minimal and is likely not clinically significant. In contrast to previous reports on military cadets, we did not find a difference in LPG between sexes. Further investigation is required to better interpret the LESS in the traditional college athletics setting.

Effects of Hyperthermia, Hypohydration and Fatigue on the Balance Error Scoring System

VanSumeren MM, DiStefano LJ, Karslo R, DeMartini JK, Huggins RA, Stearns RL, Armstrong LE, Maresh CM, Casa DJ: University of Connecticut, Storrs, CT

Context: Poor balance may increase lower extremity injury risk. Fatigue and hypohydration have been shown to individually impair balance performance, but it is unknown how these factors affect balance together, orin addition to hyperthermia. Fatigue, hypohydration, and hyperthermia commonly occur together during sport participation so it is important to understand how they may influence possibleinjury risk. **Objective:** Evaluate the effects of hyperthermia, hypo-hydration, and fatigue on balance. **Design:** Crossover trial. **Setting:** Research laboratory. **Patients or Other Participants:** Twelve trained healthy male subjects (age=20±2 yrs, height =182±8 cm, body mass=74.0±8.2 kg, body fat=9±3%, VO_{2max}= 57.0 ± 6.0 $mL \cdot kg^{-1} \cdot min^{-1}$) volunteered to participate. **Interventions:** Participants completed four randomized test sessions based on environmental conditions and hydration status (Euhydrated Temperate (EUT), Euhydrated Hot (EUH), Hypohydrated Temperate (HYT), Hypohydrated Hot (HYH)). Temperate and hot conditions were performed in 18±0.2ºC, 50±3.5% relative humidity (RH), and 34±0.3ºC, 45±4.5% RH, respectively. Hypo-hydration consisted of 22-hour fluid restriction prior to and during the session. Euhydration consisted of consuming oral fluids *ad libitum* the day prior to the session and equal to the subject's sweat rate during the session. Subjects performed a 90-minute treadmill exercise protocol (1.34-1.78 $m \cdot s^{-1}$; 5% grade) while carrying a 20.5 kg rucksack, followed by a 60-minute recovery period of quiet sitting in the test environment. Balance was videotaped and assessed using the Balance Error Scoring System (BESS) three times per session: before exercise (PRE), after exercise (POST), and after recovery (REC). The BESS requires individuals to maintain a static position in six stance-surface conditions: three stances (double-leg, single-leg, tandem), two surfaces (FIRM, FOAM). A single rater scored all trials from videotape. **Main Outcome Measures:** BESS scores from each stance-surface condition were summed to produce a total BESS score. A repeated measures analysis of variance with a Tukey HSD post hoc test evaluated differences between time (PRE, POST, REC) and condition (EUT, EUH, HYT, HYH) for BESS total score ($\alpha \leq .05$). **Results:** Body mass loss differed across sessions, which confirmed hypohydration status (EUT:0.10±0.90%, EUH:-1.30± 0.85%, HYT:-3.80±1.22%, HYH:-5.66 ±1.57%,). A main effect for condition was observed ($F_{(3,33)}$=3.79, p=.02).HYH (9.53±3.56) resulted in a higher BESS score than EUT (7.67±2.80) and EUH (8.17±3.17) and higher scores were present during HYT (8.89±3.31) compared with EUT. Regardless of condition, POST resulted in higher scores compared to PRE (7.85±2.70) and REC (8.23± 3.17) ($F_{(2,22)}$=7.99, p=.002). **Conclusions:** Hypohydration, especially in a hot environment, impaired balance ability. Fatigue also impaired balance ability after 90 minutes of exercise. These findings suggest that hydration during physical activity in the heatis critical to decrease risk of injury. These findings should also be considered during post-concussion balance assessments.

Knee Injury History Does Not Influence Jump-Landing Patterns: A Clinical Evaluation

Kulow SM, Valovich McLeod TC, Bay RC, Hackett G, Lam KC: A.T. Still University, Mesa, AZ; Grand Canyon University, Phoenix, AZ

Context: The clinical evaluation of jump-landing patterns is important for identifying individuals who may be at risk for lower extremity injuries, particularly at the knee. The Landing Error Scoring System (LESS) has been reported to be a valid and reliable method of clinically assessing jump-landing patterns. However, there is limited information regarding the influence of a previous injury on jump-landing patterns as evaluated by the LESS. **Objective:** To determine whether jump-landing movements and scores, as assessed by the LESS, differ based on knee injury history. **Design:** Cross-sectional. **Setting:** College athletic training facilities. **Patients or Other Participants:** Intercollegiate athletes who had a history of a severe knee injury (SKI), defined as an injury causing loss of participation for ≥10 days (male=12, female=25, age= 19.2±1.7 years, height= 174.4±10.7 cm, mass= 71.3± 13.6 kg), a mild knee injury (MKI), defined as an injury causing loss of participation for >1 but <10 days (male=15, female=16, age= 19.1±1.1 years, height= 174.5±11.7 cm, mass= 70.0± 11.4 kg), and no knee injury (NKI) (male=89, female=58, age=19.3±1.3 years, height= 175.2± 10.9 cm, mass=70.8±11.5 kg). **Interventions:** The independent variable was knee injury group. Participants were videotaped from the frontal and sagittal views while performing three trials of a standardized jump-landing task. Videos were later scored using the LESS (interrater reliability=.84), a 17-item, binary scoring system that counts the number of jump-landing errors (eg, knee valgus angle, foot position, stance width) an individual commits at initial ground contact and at maximum knee flexion. Each trial produces a total score and the mean

of all total scores represents an overall score (OS), with higher scores indicating poorer landing patterns. OSs were classified into one of four previously reported landing pattern groups (LPG): excellent (≤4), good (>4 to ≤5), moderate (>5 to ≤6), poor (>6). **Main Outcome Measures:** Dependent variables were the 17 LESS scoring items (SI), the OS, and the LPG. For group comparisons, chi-square tests were used for each SI and for the LPG and a one-way ANOVA with multiple comparisons was used for the OS. Alpha was $p<.05$. **Results:** SKI group (51.1%) landed with a knee valgus angle at initial contact more frequently ($x^2=7.02$, $p=.03$) than MKI (49.1%) and NKI (31.5%). There were no other group differences ($p>.05$) observed for the remaining LIs, the OS, or the LPG. **Conclusions:** Our results suggest that landing patterns and LESS scores do not differ based on a previous knee injury. While previous studies have reported sex differences, little is known about other potential group differences (eg, sport, age-group, lower extremity injury history). Future studies should continue investigating the sensitivity of the LESS in capturing potential group differences and risk factors that may be important in developing preventative programs for lower extremity injuries.

Facemask Removal is Safer than Helmet Removal in American Football

Day MA, Swartz EE, Beltz EM, Decoster LC, Mihalik JP: University of New Hampshire, Durham, NH; New Hampshire Musculoskeletal Institute, Manchester, NH; University of North Carolina, Chapel Hill, NC

Context: In cases of possible cervical spine injury, athletic trainers must be prepared to achieve rapid airway access while concurrently restricting cervical spine motion. Facemask removal, rather than helmet removal, is recommended to achieve this. However, to date this recommendation is solely supported by radiologic evidence of cervical spine alignment with and without football equipment in place. No studies of the motion created by facemask and helmet removal have been reported. **Objective:** To compare three-dimensional head motion and time of facemask (FMR) and helmet removal (HR) in two helmet styles. We hypothesized that FMR would take less time and create less motion than HR. **Design:** Repeated measures. **Setting:** Controlled laboratory. **Participants:** Seventeen certified athletic trainers (11 males, 6 females; age=32.5±9.4 yrs; experience =9.8±8.7 yrs certified; height= 171.3±9.0 cm; mass= 76.4± 14.9 kg). All participants were free from upper extremity or central nervous system pathology for 6 months and provided informed consent. **Interventions:** Independent variables consisted of removal technique (FMR or HR), and helmet type (Riddell Revolution—REV—or VSR4). After familiar-ization, participants conducted 2 successful trials for each of four conditions in random order (REV-FMR; REV-HR; VSR4-FMR; VSR4-HR). Helmets and facemasks were removed from a live model wearing a properly fitted helmet and shoulder pads. The participant and an investigator stabilized the model's head. A six-camera three-dimensional motion system, and a three-point one-segment marker set were used to record motion of the head. **Main Outcome Measures:** Dependent variables included head excursion in degrees (computed by subtracting minimum position from maximum position) in each of the three planes (sagittal, frontal, transverse), and time. A 2x2 (removal technique x helmet type) within-subjects repeated measures ANOVA was employed for each dependent variable. **Results:** We observed a main effect for removal technique across sagittal ($F_{1,16}$= 309.83; P<0.001), frontal ($F_{1,16}$= 194.52; P<0.001), and transverse ($F_{1,16}$=356.73; P<0.001) planes of motion, such that facemask removal—regardless of helmet type—resulted in less motion (sagittal=3.9°±0.2°; frontal=2.4°±0.1°; transverse= 2.7°± 0.1°) than helmet removal (sagittal =18.5°±0.9°; frontal =7.4°± 0.4°; transverse=10.3°±0.4°). We also observed a main effect of helmet type ($F_{1,16}$=9.15; P=0.008), such that removing Revolution helmets resulted in less frontal plane motion (4.5°±0.3°) than VSR4 helmets (5.4°±0.2°). Main effects of helmet type ($F_{1,16}$=71.43; P<0.001) and removal technique ($F_{1,16}$=121.39; P<0.001) for time were observed. Revolution helmets (50.0±2.7sec) were removed more quickly than VSR4 helmets (83.6 ±5.0sec). The facemask removal technique was completed in less time (37.4±1.3sec) than the helmet removal technique (96.1±6.1sec). **Conclusions:** Removing a facemask provides faster airway access with less motion in all three planes than removing a helmet in Riddell Revolution and VSR4 helmets. This validates current recommen-dations. Both removal techniques were achieved quicker with Revolution helmets than VSR4 helmets, suggesting that recent helmet designs improve airway access times.

Deflation of Air Bladders Slows Emergency Football Helmet Removal

Beltz EM, Decoster LC, Day MA, Swartz EE, Mihalik JP: University of New Hampshire, Durham, NH; New Hampshire Musculoskeletal Institute, Manchester, NH; University of North Carolina, Chapel Hill, NC

Context: Sports medicine professionals required to manage spine-injured athletes must gain quick airway access while avoiding iatrogenic sequelae. This is complicated in equipment-intensive sports (e.g., football) where protective equipment inhibits airway access. In many instances, helmet removal is required to adequately access the athlete's airway. It has been suggested helmet air bladders be deflated to decrease the difficulty of helmet removal. However, no data exists to support this recommendation. **Objective:** To determine the difficulty and total time of helmet removal (HR) across two different helmet styles and deflation status (inflated or deflated). **Design:** Repeated measures cohort study. **Setting:** Controlled laboratory. **Participants:** Twenty-two certified athletic trainers (15 males, 7 females; age=33.9±10.5 yrs; experience =11.4±10.0 yrs; height=172±9.4 cm; mass=76.7±14.9 kg). All participants were free from upper extremity or central nervous system pathology for 6 months and provided informed consent. **Interventions:** Independent variables consisted of helmet type (Riddell Revolution—REV—or VSR4) and bladder deflation status. After familiarization, participants conducted two successful trials in random order for each of four helmet removal conditions (REV-Inflated; REV-Deflated; VSR4-Inflated; VSR4-Deflated). Helmets were removed from a live model wearing a properly fitted helmet and shoulder pads. An investigator assisted in stabilizing the model's head. When ready, participants

cut chinstraps, removed cheek pads (VSR4 model only), deflated accessible bladders with an inflation needle (deflation trials only), removed the helmet, and then regained manual stabilization of the head. Total time was recorded with a digital stopwatch. The perceived level of difficulty for HR by the participant was recorded after each trial using a modified Borg CR-10 scale (RPE). **Main Outcome Measures:** Dependent variables included total time and perceived difficulty. A 2x2 (helmet type x deflation status) within-subjects repeated measures ANOVA was employed for each dependent variable. **Results:** We did not observe significant helmet type x deflation status interactions for time ($F_{1,21}$=14.81; P=0.834) or RPE ($F_{1,21}$=1.82; P=0.192). We observed a main effect for deflation status ($F_{1,21}$=18.81; P<0.001), such that inflated helmets—regardless of type—required less removal time (81.5±5.2 sec) than deflated helmets (96.1±4.9 sec). We also observed main effects of helmet type for time ($F_{1,21}$=131.51; P<0.001) and RPE ($F_{1,21}$=13.89; P=0.001), such that Revolution helmets required less time and were easier (time=59.7±3.7 sec; RPE=3.2±0.2) to remove than VSR4 helmets (time=118.0±6.7 sec; RPE=4.2±0.3). **Conclusions:** Helmet air bladder deflation prolonged the time required to remove the helmets in our study. Additionally, it is not possible to access every air bladder in a supine athlete. In combination, our results do not support deflating the helmet air bladders prior to helmet removal.

Effect of Mouthguard Use on Anaerobic Exercise Performance

Bradley L, Harrison B, Hertel J, Hoard B, Weltman AL, Saliba SA: University of Virginia, Charlottesville, VA

Context: Mouthguards are required for many sports. When not mandated, their use is often encouraged to prevent injury. The three primary categories of mouthguards are: stock, mouth formed boil-and-bite, and custom. While there are benefits to mouthguard use, compliance is an issue because of complaints regarding discomfort, difficulty speaking and breathing, cost, and fear of poor performance. **Objective:** The purpose of this study was to determine whether boil-and-bite or custom fit mouthguards affect exercise performance and to examine attitudes toward different mouthguards compared to a no mouthguard condition. **Design**: Crossover. **Setting:** University gymnasium **Patients or Other Participants:** Twenty-two healthy adults who participated in cardiovascular activity for at least 30 minutes 3 times per week volunteered (12 females, 10 males; mean age= 22 ± 2.5 years, height=169.9 ± 12.9 cm, and mass=73.4 ± 17.7 kg). **Intervention(s):** Participants completed the Yo-Yo Intermittent Recovery Test Level 1 (YIRT1) in 3 different conditions: no mouthguard, boil-and-bite mouthguard, and custom mouthguard. The order or conditions was randomized and testing in each condition occurred on different days. **Main Outcome Measures:** Meters traveled and final level of the YIRT1 attempted were recorded and analyzed using an ANOVA. Scores from a 7-point Likert questionnaire regarding, effort, performance, comfort, breathability, and function of each mouthguard were also collected following each test, then analyzed with a Chi Square Test. **Results:** Performance was not different among the three conditions on measures of meters covered (no mouthguard: 578.2 ± 305.3m; boil-and-bite: 550.9 ± 290.5m; custom: 574.6 ± 322.5m, P=0.40) or final level attempted (no mouthguard: level 14.4 ± 1.2; boil-and-bite: level 14.3 ± 1.1; custom: level 14.3 ± 1.2, P=0.25). The distribution of scores on the questionnaire differed between the boil and bite versus custom or no mouthguard in questions pertaining to ability to give full effort (no mouthguard: median = 6; boil-and-bite: 5; custom: 6, P=.02);and comfort (no mouthguard: median = 6; boil-and-bite: 5; custom: 6, P=.01). While the ability to speak (no mouthguard: median = 7; boil-and-bite: 3; custom: 6, P<.001); and breathe (no mouthguard: median = 7; boil-and-bite: 3; custom: 6, P<.001)had significantly different less favorable distributions on boil-and-bite versus no mouthguard and boil-and-bite versus custom mouthguard conditions. **Conclusions:** While no performance effects were found, athlete perceptions of decreased comfort and breathability were observed when using the boil-and-bitemouthguards. Participants did not perceive the custom mouthguards negatively, and there were no qualitative differences compared to the control condition when using a custom mouthguard during a maximal performance exercise event.

Wound Management EBF

Thursday, June 28, 2012, 5:00PM-6:00PM, Room 275; Moderator: Bernadette Buckley, PhD, ATC

Effects of Core Stability Training on Dynamic Postural Control and Global Core Muscular Endurance

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Context: It has long been thought that strength and endurance of core muscles relates to dynamic stability, and deficits influence the probability of lower extremity injury. A limited number of controlled studies exist that substantiate this clinical focus. Examining dynamic stability and core muscle endurance is an important step towards determining the efficacy of core stability training (CST) programs. **Objective:** To determine if dynamic postural stability and global core muscle endurance may be improved through CST. **Design:** Randomized controlled trial. **Setting:** Research laboratory. **Patients or Other Participants:** Twenty-seven healthy, physically active, female volunteers were randomly assigned to a CST (n=13; 21.50±1.50yrs; 163.07 ±6.35 cm; 60.57±9.95kg) or a control group (n=14; 22.10±1.30yrs; 167.74 ±6.88 cm; 68.46±15.88kg). **Interventions:** Dynamic stability and core muscle endurance were assessed before and after a 4-week intervention period in all participants. Dynamic stability was assessed with the anterior, posterior-medial and posteriorlateral reaches of the Star Excursion Balance test (SEBT). Standing on the dominant limb, three trials were completed in each direction. Global core muscle endurance was assessed with trunk flexor and extensor endurance tests, and left-side and right-side bridge tests. During each test, participants assumed and held the test position for as long as possible. The CST group participated in 4 weeks of supervised CST consisting of: single-leg bridging (left, right, prone and supine), back extension on a physioball, supine knee raise with physioball under shoulders, seated marching on the physioball, lunges onto an unstable surface, and single leg squats. The control group refrained from new physical activity during the 4-week period. **Main Outcome Measures:** Dynamic stability was assessed using the average of three trials for each reach direction, normalized to leg length (%). The global core muscle endurance tests were measured in seconds. Each dependant variable was represented as a pre-post change from baseline (Δ). For each outcome, an independent t-test was performed. Additionally, effect sizes (Cohen's d) with associated 95% confidence intervals were calculated. Significance was set a priori at $P<.05$. **Results:** Participants in the CST group had significantly greater pre-post improvements compared to the control group in the posteriorlateral reach ($t_{25}=2.91$; P=0.007; CST: Δ9.58± 6.46%; Control: Δ2.23± 6.63%; d=1.12, 95%CI: 0.28,1.90), posterior-medial reach ($t_{25}=2.15$; P= 0.042; CST: Δ5.27±7.18%; Control: Δ-0.99±7.91%; d=0.83, 95%CI: 0.02,1.59), right-side bridge ($t_{25}=2.46$; P =0.021 ; CST: Δ14.54±15.10sec; Control: Δ-2.50±20.22sec; d=0.95, 95%CI: 0.13, 1.17) and left-side bridge ($t_{25}=3.44$; P= .002; CST: Δ20.92 ±15.68sec; Control: Δ-1.86± 18.46 sec; d=1.33, 95%CI: 0.46, 2.11). **Conclusion:** Dynamic stability and global core muscle endurance were improved after a 4-week core stability training program in healthy females. Future research will need to determine if similar interventions can be useful at preventing injury and improving outcomes for rehabilitation of injured populations.

Muscle Activation during the Active Straight Leg Raise and Double Straight Leg Lowering Tests

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Context: Low back pain is a common medical condition that exists in athletic and general populations. However diagnosing low back pain is difficult for clinicians because no gold standard clinical test has been established. Limited research has assessed muscle activation during commonly used clinical tests that evaluate low back pain. **Objective:** To assess muscle activation during the double straight leg lowering (DSLL) and active straight leg raise tests. The active straight leg raise was performed bilaterally. **Design:** Within subject cohort study. **Setting:** Neuromechanics Research Laboratory. **Participants:** Thirty healthy, physically active, college aged (173.5 + 9.15cm, 73.9 + 17.1kg, 21 + 2yrs) participants were recruited from a university campus. **Intervention:** Muscle activation was assessed bilaterally during the DSLL, right active straight leg raise (RASLR), and left active straight leg raise (LASLR) during one data collection session. The order of clinical tests was counterbalanced. **Main Outcome Measures:** The dependent variable was muscle activation. Muscle activation (mean and peak) of the transverse abdominis / internal oblique (TrA/IO), external oblique (EO), and rectus abdominis (RA) were measured using the Myomonitor IV (Delsys, Boston, MA) during the DSLL, RASLR, and LASLR. Independent samples t-tests were used to assess muscle activation differences between the clinical tests. **Results:** No differences were observed in the TrA/IO between the DSLL and ASLR. Greater mean muscle activation was observed in the EO (right- p = 0.006; left- p

=0.020) and RA (right- p =0.004; left- p=0.044) during the DSLL than the RASLR. The EO (right- p= 0.044; left p =0.003) and right RA (p = 0.002) had greater mean muscle activation during the DSLL than the LASLR. Greater peak EO (right- p = 0.016; left- p =0.028) and right RA (p= 0.003) muscle activation was observed during the RASLR than the DSLL. The left TrA/IO had greater peak (p= 0.012) muscle activation during the LASLR than the RASLR. Greater peak muscle activation was observed in the left EO (p = 0.005) and right RA (p = 0.001) during the LASLR and DSLL. The right TrA/IO (p = 0.045) had greater mean muscle activation during the RASLR than the LASLR. The left TrA/IO (p = 0.012) had greater mean muscle activation during the LASLR than the RASLR. **Conclusion:** Greater TrA/IO muscle activation was observed during the active straight leg raise than the DSLL. The DSLL activated the EO and RA more than the ASLR. Activation patterns vary depending on which leg is raised during the ASLR. Greater TrA/IO muscle activation was observed on the lifting leg side. This data suggest that clinicians may want to use the active straight leg raise test to assess a patient's TrA/IO muscle activation while the DSLL appears to be better at assessing EO and RA muscle activation.

Effect of Dosage ofTrunk and Hip Integrative Neuromuscular Training on Hip Abductor Strength Development in Female Athletes

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Context: Recent studies demonstrate the mechanistic link between reduced proximal neuromuscular controland increased risk for knee injuries including anterior cruciate ligament (ACL) and patellofemoral injuries in female athletes. In addition, specific proximal controllers such as frontal plane hip strength and recruitment are reported to modulate knee kinematics related to injury risk during dynamic movements. Meta-analytic reports indicate that the efficacy of integrative neuromuscular training (INT) is strongly associated with compliance and dosage to the prescribed programming. **Objective:**To investigate the association of compliance anddosage with a trunk and hip focused INT to improve isokinetic hip abductor strength in young female athletes. **Design:** Controlled laboratory. **Setting:**High school and research laboratory. **Participants:** Twenty-one high school female volleyball players (mean age 15.6±1.4 years, weight 64.0±7.4 kg, height 171.5±7.0 cm) were recruited.Seven untrained subjects were included in the analysis to serve as the "zero" compliance cohort. **Interventions:** A five phase supervised progressive trunk and hip focused INT program aimed to improve trunk and hip strength, power, and dynamic stabilization was implemented twice a week for ten weeks in addition to a routine strength training, which was performed once per week.**Main Outcome Measures:** Bilateral isokinetic hip abductor peak torque at 120°/second was measured at pre- and post-intervention by the Biodex 3 system. To analyze dosage effect of the trunk and hip focused INT on isokinetic hip abductor peak torque,both INT session and specific trunk and hip exercise compliance rateswere recorded. Pearson correlation coefficients were calculated to evaluate the association between INT session compliance, specific trunk and hip exercise compliance and changes in isokinetic hip abductor peak torque. **Results:** The participants demonstrated a 9.3% increases in isokinetic hip abductor peak torque at post-testing (52.8±9.3 ft-lbs) compared to the pre-testing values (48.3±9.6 ft-lbs; 95% confidence interval [1.4, 7.6]).The correlation coefficient (r) between the INT session compliance rate and the isokinetic hip abductor peak torque changewas0.56(p=0.009). Similarly, the rvalue between the specific trunk and hip exercise compliance rate and the isokinetic hip abductor peak torque change was0.59 (p= 0.005).**Conclusions:**A supervised progressive trunk and hip focused INT for twice per week for ten weeks enhanced hip abductor strength in young female athletes. A significant association was found between the hip abductor strength improvement and the trunk and hip focused INT compliance. An apparent dose-response relation-ship was observed with increased INT sessions and specific trunk and hip focused exercises completed andthe greater hip abductor strength improvement.Adaptations from trunk and hip focused training that improve hip abductor strength and recruitment may be protective against high knee abduction/valgus loading during dynamic movements, and potentially reduce ACL and patellofemoral injury risk in young female athletes.

Isometric Hamstrings to Quadriceps Mean Torque Ratio after Exercise in Persons with a History of Low Back Pain

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Context: Non-specific Low back pain(LBP) is a problem for active persons due to high prevalence and recurrence.Muscle weakness and imbalance is common in those with LBP. The role of hamstring and quadriceps function over the course of exercise has been implicated as a causative factor in recurrent episodes of LBP in active individuals. **Objective:** To compare hamstring to quadriceps(H:Q) isometric mean torque ratios, mean biceps femoris EMG activation, and mean vastus lateralis EMG activation in participants with and without LBP afterexercise. **Design:** controlled laboratory study. **Setting:** Research laboratory. **Patients or Other Participants:** 34 recreationally active participants; 17 with recurrent episodes of LBP: age=22.8±3.6yrs, height=169.7±10.6cm, weight=68.7±

12.8kg) and 17 matched controls. Participants with LBP had experienced at least 3 episodes of non-specific LBP in the past 12 months (at least 1 in the past 6 months) **Interventions:** Participants performed 30 minutes of submaximal exercise including 5 repeating cycles of low intensity anaerobic and aerobic exercise. The aerobic component of each cycle consisted of 5 minutes of uphill walking withgraduallyincreasing incline (1 degree per minute, maximum 15 degrees of incline) immediately followed by 1 minuteofcontinuous body weight squats step-up exercises.**Main Outcome Measures:** Patients performed a 5 second seated knee extension and knee flexion maximal voluntary isometric contraction with the knee bent to 60-degrees. Mean isometric torque was measured during the middle 3 seconds of each contraction and normalized to body mass. A ratio of mean knee flexion torque to mean knee extension torque was then generated. Mean vastus lateralis and biceps femoris root mean squared EMG activity was measured during the same time epoch used to measure mean isometric torque. Three separate 2 (Group: healthy, LBP) x 2 (Time: pre-exercise, post-exercise) repeated measures ANOVAs were used to analyze differences between groups before and after exercise. **Results:** There was no significant groupXtime interaction for H:Q mean isometric torque ratio(Healthy: pre-exercise= 0.64± 0.13, post-exercise=0.68±0.33; LBP: pre-exercise=0.55±0.11,post-exercise=0.53±0.16, p=0.89) or main effect for time(*P*= 0.25) however, there was a significant main effect for group indicating significantly lower H:Q ratio in participants with LBP compared to controls(P=0.05). There was no significant groupXtime interaction (P=0.23) or group main effect (P=0.90) for mean hamstring EMG activation however, a significant increase was seen following exercise for all(P=0.01). There was no significant groupXtime interaction (P=0.66), group main effect(P= 0.52) or time main effect(P=0.08) for mean quadriceps EMG activation. **Conclusions**:Thirty minutes of low intensity aerobic and anaerobic exercises did not result in an altered response for patients with recurrent episodes of LBP when compared to controls. Since previos studies have observed altered responses following continuous aerobic exercise, this exercise protocol may provide a way for patients with LBP to exercise while avoiding potentially different responses.

Increased Active Hamstring Stiffness 48 Hours After Exercise in Females with Recurrent Low Back Pain

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Context: Patients with repeated episodes of low back pain (LBP) experience neuromuscular adaptations during aerobic exercise due to poor core stability. Deteriorated quadriceps neuromuscular function after exercise have been reported in LBP patients however, the response of the hamstrings is unclear. **Objective:** To compare active hamstring stiffness in female subjects with and without a history of LBP after a standardized 20-minutes of aerobic exercise. **Design:** Case-control. **Setting:** Laboratory. **Patients or Other Participants:** Twelve females with a history of recurrent episodes of LBP (age= 22.4±2.1yrs; mass= 67.1±11.8 kg; height= 167.9± 8cm) and 12 matched healthy females (age=21.7± 1.7yrs; mass= 61.4±8.8kg; height= 165.6± 7.3cm) participated. **Interventions:** Partici-pants walked approximately 4.8kph for 20-minutes on a treadmill. The treadmill incline was raised 1% grade per minute. During the last 5-minutes, participants adjusted the incline of the treadmill so they would maintain a moderate level of perceived exertion through the end of the exercise protocol. **Main Outcome Measures:** Each participant completed 2 testing sessions. Session 1: Active hamstring stiffness, maximum knee extension and flexion isometric torque, and surface electromyographic (EMG) root mean square activation of the lateral hamstring and lateral quadriceps during a 5-second maximal isometric contraction were recorded before and immediately after aerobic exercise. Session 2: Subjects returned 48 hours following exercise for a repeat measure of active hamstring stiffness. Active hamstring stiffness was calculated using a published formula utilizing the dampened frequency of oscillation. For this measure, subjects lay prone on a treatment table with the knee and hip flexed to 30 degrees. While the subject held their shank-foot segment parallel to the floor (with external weight equal to 10% subjects' mass fixed to the ankle), a sudden downward perturba-tion was applied causing the knee to extend. The dampened frequency of oscillations was measured as the time between acceleration peaks as the subject recovered from the per-turbation. Average, normalized knee extension and flexion isometric torque was calculated for the middle 3-seconds of a 5-second isometric contraction at 60-degrees of knee flexion. One-way ANCOVAs were used to compare post-exercise session 1 and session 2 measures between groups. The baseline values were used as a covariate. **Results:** When adjusted for baseline scores, there were no group differences in active hamstring stiffness immediately following exercise (LBP=41.4 ±17.2Nm/rad, Control =32.9±8.0Nm/rad, P=.39). There were no differences in EMG activation or normalized torque immediately after exercise. However, the LBP group exhibited significantly increased hamstring active stiffness 48-hours post-exercise (40.2±16.3Nm/rad) compared to controls (27.9±7.0Nm/rad, P=.03). **Conclusions:** Females with LBP presented greater active hamstring stiffness at 48 hours after aerobic exercise. This may be an adaptive response of the hamstrings to exercise in patients with recurrent LBP who may have poor strength and endurance in the muscles that support the lumbo-pelvic-hip regions.

Free Communications, Oral Presentations: Effects of Concussion on Gait and Balance

Friday, June 29, 2012, 9:30AM-10:45AM, Room 260-267; Moderator: Johna Mihalik, PhD, ATC

Acute Concussion Impairs Dual Task Gait Performance

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Context: Acute concussion impairs both postural control and cognitive processing; however, these two neurological components are typically tested independently. Recent studies have suggested dual task assessment, the simultaneous challenge of maintaining postural stability while performing a cognitive task, may be an effective method of identifying post-concussion neurological impairments. **Objective:** The purpose of this study was to identify impairments in postural control during dual task gait. We hypothesized post-concussion participants would demonstrate a conservative gait pattern. **Design:** Cross sectional. **Setting:** Biomechanics laboratory. **Patients or Other Participants:** The concussion group consisted of 17 student-athletes (age: 19.7 + 1.5 years, height: 1.73 + 0.15 m, weight: 89.9 + 7.9kg) who had recently suffered a concussion (13/17 Grade II, Cantu Evidence Based Grading scale) and 17 gender matched control participants (age: 20.6 + 1.2 years, height: 1.74 + 0.89m, weight: 79.5 + 4.5kg) who had never suffered a concussion. **Interventions:** All participants completed five trials of dual task gait utilizing working memory challenges: days of the week backwards, months of the year backwards, subtraction by 7, spelling a 5 letter word backwards, and consecutive addition. All concussion participants were tested within 24 hours of suffering the concussion. **Main Outcome Measures:** Gait trials were performed on a 4.9m instrumented walkway which has previously been identified as both valid and reliable. The dependent variables of interest included gait velocity, stride length, heel-to-heel base of support, and percentage of the gait cycle in single support and percentage of the gait cycle in swing phase and were compared between groups by t-tests. **Results:** The post-concussion participants demonstrated a conservative gait pattern including significant reductions, compared to control participants, in gait velocity (1.21 + 0.17m/s and 1.37 + 0.16m/s, p= 0.010), stride length (1.33 + 0.13m and 1.42 + 0.11m, p=0.043), single support phase (37.9 + 1.4% and 39.0 + 1.1%, p=0.025), and swing phase (37.9 + 1.4% and 39.0 + 1.3%, p=0.034). There was no difference in heel-to-heel base of support (15.8 + 6.4cm and 14.4 + 4.3cm, p=.448). **Conclusion:** The results of this study suggest that the addition of a cognitive task impairs gait performance following a sports-related concussion. Previous studies utilizing dual task gait assessment involved the time consuming process of complete biomechanical marker set-up; however these results suggest that these impairments can be identified with an instrumented walkway. These findings support the recent trend in the literature to assess both the cognitive and postural control systems simultaneously following a concussion.

The Role of Age and Sex on Symptoms, Neurocognitive Performance, and Postural Stability in Athletes following Concussion

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Context: Research has shown age and sex differences in concussion outcomes. However, little is known about the interactive effects of age and sex on symptoms, neurocognitive testing (NCT), and postural stability. **Objective:** The purpose of the study was to examine sex and age differences in symptoms, NCT, and postural stability following concussion. We hypothesized that males and younger athletes would have worse symptoms, NCT, and postural. **Design:** Prospective cohort study **Setting:** This study was performed in a controlled laboratory setting. **Patients or Other Participants:** A total of 222 concussed athletes from a multi-state, two-year study volunteered to participate and were classified as college males (n= 37,age =19.5±1.08 years, mass =93.8±15.6 kg, height =183.8±7.24 cm), college females (n =35 , age =18.9±1.55 years, mass =66.7±9.1 kg, height =170.3±8.22 cm) high school males (n=121 , age =15.5±1.19 years, mass =76.6±15.5 kg, height =176.6 ±7.59 cm), high school females (n= 31,age =15.4±1.22 years, mass =63.9±10.4 kg, height =164.4±7.13 cm). **Interventions:** The independent variables in this study were time (baseline, 2, 7, and 14 days post-concussion), sex (male, female), and age (high school, college). Partici-pants completed the Immediate Post-concussion Assessment and Cognitive Test (ImPACT) and Post-concussion Symptom Scale (PCSS) at baseline; and at 2, 7, and 14 days post-con-cussion. Participants completed the Balance Error Scoring System (BESS) at 1, 2, and 3 days post-concussion. **Main Outcome Measures:** Dependent variables included ImPACT composite scores (verbal/ visual memory, reaction time, processing speed), PCSS scores, and BESS scores. A 4 (time) x 2 (sex) x 2 (age) repeated measures ANOVA was performed to compare group differences in concussion symptoms and ImPACT composite scores and another 3 (time) x 2 (sex) x 2 (age) ANOVA was performed to compare

group differences in BESS scores. Post-hoc comparisons were performed using Tukey's HSD, and *a priori* statistical significance was set at = 0.05, and the Bonferroni was applied for multiple comparisons. **Results:** Females performed worse than males on visual memory (M=65.1±15.7: 70.1±15.4, $F_{(1,118)}$, 3.95, *P*=.049, η^2= .032) and reported more symptoms (M=14.4±6.7: 10.1± 10.3, $F_{(1,118)}$, 4.53, *P*=.035, η^2=.037). High school athletes performed worse than college athletes on verbal (M= 78.8±12.5: 82.7±13.7, $F_{(3,116)}$, 8.03, *P*= .001, η^2= .171) and visual (M=65.8±16.1: 69.4±15.6, $F_{(3,116)}$, 3.64, *P*=.02, η^2= .09) memory. High school males scored worse on the BESS than college males (M= 18.8 ±8.4: 13.0±6.8, $F_{(1,111)}$, 7.29, *P*=.008, η^2= .061). College females scored worse on the BESS than high school females (M=21.1±6.9: 16.9±8.7, *P*=.008). **Conclusions:** The findings from the current study suggest that concussed high school and collegiate athletes exhibit different outcomes following concussion. Specifically, age and sex should be considered when interpreting symptoms, NCT, and postural instability following concussion.

Neurocognition and Postural Control of Asymptomatic Concussed Athletes Compared to Healthy Controls

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Context: Previous studies suggest that concussed athletes may present with postural control and neurocognitive deficits despite reporting full resolution of concussion-related symptoms. Relying solely on a concussed athlete's reported symptoms could prompta premature return to play prior to full recovery. Further research is necessary to determine if other concussion assessment tools identify similar deficits in asymptomatic concussed athletes. **Objective:** To determine if neurocognitive and postural control performance differ between asymptomatic concussed athletes and non-concussed controls. **Design:** Prospective cohort design. **Setting:** Clinical research laboratory. **Patients or Other Participants:** Forty-three Division I collegiate student-athletes were assigned to our concussed group (n=27; male=14, female=13; age= 19.4 ±1.1 yrs; height=177.4±10.9 cm; mass= 78.3± 14.3 kg) or non-concussed control group (n=18; male=7, female=11; age=18.3±0.6 yrs; height=171.3±7.9 cm; mass= 68.6± 11.0 kg). **Interventions:** Between 2010-2011, 438 student-athletes completed a preseason baseline postural control exam (SOT; Sensory Organization Test), a computerized neurocognitive test (CNSVS; CNS Vital Signs), and a graded symptom checklist as part of an on-going concussion management program. Twenty-seven athletes were later diagnosed with a sport-related concussion, and completed post-injury testing once the athlete reported resolution of concussion-related symptoms (7.5±4.1 days post-injury, 137.6±109.2 days post-baseline). Eighteen non-concussed control athletescompleted a post-test approximately 10-weeks (69.9±1.6 days) after baseline. Athletes were considered asymptomatic at post-test if their total symptom severity score was no greater than 2 points higher than their baseline. Post-test symptom severity scores did not differ between groups ($F_{1,43}$=1.3, p=0.266). **Main Outcome Measures:** Change scores (post-test score – baseline score)were computed for the SOT composite score and the following CNSVSStandard Scores: Composite memory, Psychomotor speed, Reaction time, Complex attention, Cognitive flexibility, Processing speed, Executive functioning, and Reasoning. Positive values represented improvements and negative values represent declines. Separate one-way ANOVA models were used to assess between-group differences for each outcome measure with an a priori alpha level of 0.05.**Results:** Despite reporting symptom resolution, the concussed group performed significantly worse than the control group on Psychomotor Speed(Concussed= -1.8±11.7; Control=8.2±13.8; $F_{1,43}$= 6.9, P=0.012). The concussed group presented with trends toward poorer performance compared to the control group on Pro-cessing speed (Con-cussed=0.89±10.2; Control =8.7± 17.0; $F_{1,43}$=3.7, P= 0.062). No other significant differences were observed. **Conclu-sions:** Athletes denying symptoms following concussion may still present with declines in select neurocognitive domains as measured by CNSVS. Our results agree with previous studies using different neurocognitive test batteries and support the use of computerized neurocognitive testing as a means of identifying declines in performance after self-reported symptom resolution. A graded symptom checklist should not be used in isolation, but incorporated as part of a multifaceted approach to concussion evaluation. Future research is necessary to determine whether the observed differences in asymptomatic concussed athletes performance exceeds reliable change indices, indicating clinically meaningful declines in neurocognitive performance on CNSVS.

Dynamic Postural Control is Not Impaired in Individuals with Multiple Concussions

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Context: Recent evidence has suggested that a history of multiple concussions, typically defined as three or more, may result in long-term neurological impairments. The influence of multiple concussions on postural control during transitional movements has not previously been investigated. Gait initiation, literally the act of starting to walk, has successfully identified impairments in postural control in a wide range of patient populations with neurological pathologies. **Objective**: The purpose of this study was to investigate performance of cued gait initiation in individuals with a self-reported history of three or more concussions. We hypothesized that individuals with a history of multiple concussions would reduce the displacement of the center-of-pressure (COP) and restrict the separation of the center-of-mass (COM) and COP. **Design**: Cross sectional. **Setting**: Biomechanics laboratory. **Patients or Other Participants**: Ten individuals, current or recent student-athletes with a history of at least three self-reported concussions (6M/4F, age: 20.6 ± 1.2 years, ht: 1.77 ± 0.12m, wt: 83.8 ± 23.9kg, 3.5 ± 1.0 previous concussions, range: 3 – 6) were closely matched to 10 current student-athletes (6M/4F, age: 20.5 ± 1.6, ht: 1.76 ± 0.11m, wt: 83.6 ± 23.0 kg) of the same sport with no self-reported history of concussion or likely concussion symptoms; direct or indirect head impacts associated with loss of consciousness, post-traumatic amnesia, or similar. **Interventions**: Both groups performed 5 trials of cued GI at a self-selected velocity. Participants began each trial standing on two 40x60cm forceplates to collect kinetic data (1,000 Hz) and were set-up with 39 retroreflective markers to calculate kinematic data (100 Hz). **Main Outcome Measures**: The dependent variables of interest included displacements of the COP during the anticipatory postural adjustment phase, the initial step characteristics, and the separation of the COP-COM at the conclusion of the single stance phase of the initial step. Dependent variables were compared between groups with one-way ANOVAs. **Results**: There were no between group differences, between concussion and control respectively, for posterior COP displacement (5.24 ± 1.14cm and 4.88 ± 1.10cm, p=0.48), lateral COP displacement (6.01 ± 1.07cm and 6.54 ± 0.97cm, p=0.26), initial step length (0.64 ± 0.04m and 0.61 ± 0.06m, p=0.21), initial step velocity (0.67 ± 0.06m/s and 0.65 ± 0.04m/s, p=0.60), or peak separation of the COP-COM (30.7 ± 3.2cm and 30.2 ± 2.7cm, p=0.68). **Conclusion**: The results of this study suggest that, during the transitional movement of gait initiation, there were no differences in dynamic postural stability in individuals who had suffered at least three previous concussions. It is possible that, at these relatively young ages, the multiple concussion individuals have sufficient compensatory mechanisms available to offset any early neurological impairments, if present, which would impair postural control.

Does Concussion History Affect Postural Control As Measured By the Stability Evaluation Test?

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Context: Concussion is a complex pathophysiological process that injury can affect memory, judgment, reflexes, speech, balance, and coordination. Concussion evaluation uses balance assessment to determine the function of the motor domain of neurological functioning. The Stability Evaluation Test (SET) is an instrumented version of the Balance Error Scoring System (BESS) performed on a portable force platform system that has been newly introduced to the sports medicine community. The system allows for an objective assessment of sensory and voluntary motor control of balance. **Objective:** To determine if baseline postural control values measured by the SET differ based on concussion history. **Design:** Cross-sectional. **Setting:** High school and collegiate athletic training facilities.**Patients or Other Participants:** Interscholastic and Inter-collegiate athletes with (n=30, age= 19.2±1.3 years, height= 176.8± 13.7 cm, mass=76.2±13.5 kg) and without (n=175, age=19.4±1.3 years, height= 174.9±10.7 cm, mass= 70.2± 11.9 kg) a self-report history of con-cussion.**Interventions:** The independent variable was concussion history; positive vs. negative. All participants completed the SET, which involves 6 20-second balance tests with eyes closed, using the stances of the BESS: double-leg firm (DFi), single-leg firm (SFi), tandem firm, (TFi), double-leg foam (DFo), single-leg foam (SFo), and tandem foam (TFo). **Main Outcome Measures:** The dependent variable was sway velocity (SV)for each of the 6 SET conditions. A composite SET sway velocity variable was also analyzed. Sway velocity (deg/sec) is defined asthe ratio of the distance traveled by the center of gravity to the time of the trial. A higher score indicates more sway (worse balance). A 2 (group) by 6 (condition) repeated measures analysis of variance was used to evaluate differences in SV. An independent t-test assessed differences in the composite SV variable. **Results:**The interaction for SV was not significant (P=.526), nor was the main effect for group (P=.190). There was a significant main effect for condition (P<.001) with DFi (0.74±0.20deg/sec)<TFi (1.66± 0.81deg/sec) < SFi (2.23± 0.83deg/sec) < DFo (2.97±0.89deg/sec) < SFo (4.69±1.3deg/sec) = TFo (5.12± 2.24deg/sec).The composite SV did not differ (P=.197) between

participants with (3.05±0.62deg/sec) and without (2.89±0.63deg/sec) a concussion history.**Conclusion:** A previous history of self-reported concussion does not alter postural control as measured by the SET. Differences in sway velocity were noted between the six conditions of the test with those on the foam surfaces demonstrating the largest sway velocities. Our findings suggest that the SET may be a useful clinical tool in assessing postural stability in the athletic population. However, more studies need to be conducted to gain a better understanding of its use in the sports medicine community. Further work should continue to evaluate the utility of the SET for the evaluation of postural control in athletes following concussion and musculoskeletal injuries.

The Effect of a 4-Week Wobble Board Rehabilitation Program on Improving Functional Ankle Instability

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Context: Rehabilitation protocols using multiple exercises have been shown to improve balance and decrease ankle sprain incidence in individuals with functional ankle instability (FAI). While these outcomes are desired, evidence is lacking on how each specific exercise in rehabilitation programs contribute to improving self-reported outcomes. Self-perceived functional instability following an injury is important to quantify confidence in one's ability to return to competition. **Objective**: To quantify improvements in self-reported functional instability using a single ankle rehabilitation exercise as a therapeutic intervention. **Design**: Prospective, randomized controlled experimental design. **Setting**: Research laboratory. **Patients or Other Participants**: Twenty-eight subjects with "giving way" and a history of ankle sprains (i.e. FAI) were participants. Fourteen subjects (170.22±8.71 cm, 75.57±13.55 kg, 22.94±2.77 yrs) were randomly assigned to a rehabilitation group (REH) and fourteen subjects (168.57±9.81 cm, 77.19±19.93 kg, 23.18±3.64 yrs) were randomly assigned to a control group (CON). **Interventions**: Completion of the Cumberland Ankle Instability Tool (CAIT) was either followed by 4 weeks with no intervention for CON subjects or wobble board training for REH subjects. Rehabilitation protocol consisted of 3 sessions per week. Subjects performed 5 wobble board repetitions, with each repetition consisting of alternating 10 seconds of clockwise circles and 10 seconds of counterclockwise circles on the limb with FAI for a total of 40 seconds. Both groups were posttested 4 weeks after their pretest. A two (group: CON, REH) by two (test: pre, post) repeated measure ANOVA was used for data analysis (α=.05). Tukey's HSD post-hoc tests were conducted on significant interactions. **Main Outcome Measures**: Dependent measure was CAIT score. A higher score indicated improved self-reported functional stability. **Results**: Main effect for time was significant (P=0.021), but main effect for group was not (P=0.06). A significant group by test interaction was found (REH_{pre}=16.79±4.90, REH_{post} =22.86 ±4.83, CON_{pre}=17.00±4.59, CON_{post}=16.43±6.03; $F_{(1,26)}$=8.88, P=0.006). Post-hoc testing showed that groups were not different at pretest. Posttest score for the REH group was greater than pretest score; the CON group did not improve at posttest. Lastly, posttest score for the REH group was greater than the pre- and post- test scores for the CON group. **Conclusions**: Wobble board rehabilitation improved self-reported functional stability in subjects with FAI. We suggest utilizing this wobble board program to improve self-perceived functional stability. Future research should examine how long the improvements in self-reported functional stability last (ie. 1 month, 6 months, 1 year). Funded by the NATA Foundation Doctoral Grant Program.

Quadriceps Central Activation Ratios Following 2-weeks of Rehabilitation Exercises Augmented with Cryotherapy

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Context: Persistent muscle weakness following ACL reconstruction may be due to underlying activation failure and arthrogenic muscle inhibition (AMI). Knee joint cryotherapy has been shown to improve quadriceps function transiently in those with AMI thereby providing an opportunity to improve quadriceps muscle activation and strength in ACL reconstructed patients.**Objective:**To compare quadriceps strength and central activation a before and after an intervention with or without knee joint cryotherapy. **Design:** Randomized, Blinded Clinical Trial**. Setting:** Laboratory. **Patients or Other Participants:** Thirty patients (27.3±11.4years, 167.4±8.8cm, 73.3± 12.2kg) with primary, unilateral ACL reconstruction at least 6 months prior and with measurable quadriceps central activation failure (defined as a central activation ratio <90%**. Interventions:**Patients were randomly allocated to 1 of 3 groups. Exercise group(EXER): patients attended four, 2-hour supervised exercise sessions over a 2-week period consisting of traditional weight bearing and non-weight bearing resistance exercises. Cryotherapy+Exercise group (CRYO +EXERC): patients received a 20-minute knee joint cryptherapy treatment (an ice bag secured to the anterior and posterior knee with a compression wrap) and then performed the same exercise program as mentioned above. Cryotherapy Group(CRYO): patients received a 20 minute knee joint cryotherapy treatment during each session. All patients were given a home program with a compliance log matching group assignment. **Main Outcome Mea-**

sures: A blinded assessor measured knee extension maximal volitional isometric contraction (MVIC) torque and quadriceps CAR before and after the 2-week exercise period using the superimposed burst technique. An external stimulus was applied to the quadriceps during the MVIC causing a brief increase in torque (SIB torque). Central activation ratio (CAR) was calculated as [MVIC/MVIC+ SIB) *100]. We used an ANCOVA (covariate=baseline measure) to compare CAR and MVIC torque following the intervention period. Post hoc tukey's LSD determined differences between groups. Data are presented as adjusted ($_{ADJ}$) means ±standard deviationand average percent change from baseline-post intervention with associated [95% confidence intervals]. **Results:** Quadriceps CAR following the 2 week intervention period were significantly different among the treatment groups ($F_{2,26}$=3.47, P=0.046). CAR_{ADJ} in the CRYO+EXERC group (CAR_{ADJ}= 88.1± 2.3%, 17.7%[7.6,27.8]) was significantly higher than the CRYO group (CAR_{ADJ} =79.4±2.3%, 2.75%[-5.1,10.6], P=0.01) but there was no difference between the CRYO group and EXERC group(CAR_{ADJ} =84.3±2.4%, 16.2%[2.7,29.7], P= 0.26) or the EXERC and CRYO +EXERC group (P=0.16). There was also significant differences in adjusted means for normalized MVIC among the treatment groups ($F_{2,26}$=3.42, P=0.048). Normalized MVIC in the CRYO+EXERC ($MVIC_{ADJ}$ =2.1 ±.13Nm/kg,38.2% [18.2,58.1])group was significantly higher than the EXERC ($MVIC_{ADJ}$=1.71±.13Nm/kg, 16.8%[-2.1,35.8], P=0.029) and CRYO ($MVIC_{ADJ}$=1.75±.12Nm/kg, 15.5%[-1.8,32.8], P=0.035) groups. There were no differences in normalized MVIC between the EXERC and CRYO groups (P=0.889). **Conclusions:** The strategic implementation of knee joint cryotherapy immediately prior to controlled, low intensity rehabilitation exercises appears to facilitate strength gains in patients with inhibited quadriceps following ACL reconstruction.

The Effect of an Eight-Week Abdominal Training Program on Muscle Activation in Healthy and Chronic Ankle Instability Subjects

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Context: Chronic ankle instability (CAI) subjects have demonstrated altered lower extremity muscle activation. Increased lower extremity muscle activation was observed during previous research when the transverse abdominus was voluntarily contracted during a prone hip extension. Abdominal training has been theorized to decrease the risk of lower extremity injuries. The affect abdominal training has on abdominal & lower extremity muscle activation is unknown. **Objective:** To determine if abdominal training changes abdominal or lower extremity muscle activation during a single-leg drop landing. **Design:** A 3 x 2 (group x time) cohort design. **Setting:** Biomechanics Laboratory. **Patients or Other Participants:** Sixty subjects were divided into three groups (Control, Healthy, and CAI). Subjects in the Control and Healthy groups did not have a history of ankle instability. Nineteen Control (22± 3yrs, 74.1±13.8kg, 172.6± 11.3cm), 21 CAI (22±2yrs, 77.6± 14.0kg, 175.4± 12.3cm), & 20 Healthy (23 ±3yrs, 70.9 ±15.6kg, 172.2± 8.9cm) subjects participated. Subjects were matched by gender, height, and leg dominance. CAI subjects self-reported a history of CAI & functional ankle instability. The Ankle Instability Index & Functional Ankle Ability Measure confirmed CAI & functional ankle instability respectively. **Interventions:** The CAI & Healthy groups participated in an 8 week abdominal training program while the Control group maintained their activities of daily living & fitness level. Muscle activation was assessed pre-and post-training during a single-leg drop landing. **Main Outcome Measures:** Muscle activation was the dependent variable. The Myomonitor IV (Delsys, Boston, MA) was used to measure muscle activation of the transverse abdominus/internal oblique (TrA/IO), external oblique (EO), gluteus medius (GMed), & vastus medialis (VM). Muscle activation was normalized using maximal voluntary contractions. A repeated measures ANOVA was used to analyze normalized muscle activation. Post-hoc testing with a Bonnforoni adjustment determined differences between & within groups. **Results:** Normalized mean pre-training (*Control*– TrA/IO; 311.7±176.2: EO; 194.5±101.8: GMed; 91.2±69.0: VM; 520.5±719.5, *CAI*- TrA/IO; 855.0± 1038.2: EO; 328.4±163.6: GMed; 109.4±62.2: VM; 611.3±478.4, *Healthy*- TrA/IO; 503.6±481.5: EO; 148.7±56.3: GMed; 65.6±29.9: VM; 665.8±726.5) & post-training (*Control*- TrA/IO;378.7±510.3: EO; 138.3±97.1: GMed; 70.5±20.0: VM; 202.6±82.7, *CAI*– TrA/IO; 365.0± 292.3: EO; 287.9±602.5: GMed; 91.8±43.6: VM; 219.7±145.8, *Healthy*– TrA/IO; 332.8±572.3: EO; 127.7±187.0: GMed; 50.2±23.4: VM; 157.4±66.7) muscle activation (%) were measured. Before training the CAI group had greater activation than the Control (TrA/IO; p= 0.039: EO; p= *0.002*) & Healthy groups (EO; p< 0.001: GMed; p= 0.040). Muscle activation decreased following training in the CAI (TrA/IO; p= 0.003: VM; p= 0.020) & Healthy (VM; p= 0.02) groups. The CAI group had greater activation than the Healthy (EO; p= 0.020: GMed; p= 0.002) group following training. **Conclusions:** CAI subjects utilize their abdominal muscles more than healthy subjects during a dynamic task to maintain postural control. Eight weeks of abdominal training may improve abdominal & lower extremity neuromuscular efficiency.

The Influence of Age on the Effectiveness of Neuromuscular Training to Reduce Anterior Cruciate Ligament Injury in Female Athletes: A Meta-Analysis

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Context: Sports related injuries to the anterior cruciate ligament (ACL) increase during adolescence and peak in incidence during the mid to late teens for females. In response to the evidenced high rates of injuries, neuromuscular training (NMT) programs are often prescribed to reduce the ACL injury incidence in these populations. Longitudinal biomechanical investigations indicate that a potential window of opportunity is present prior to the peak injury incidence, which would be optimal timing for the initiation of integrative NMT in female athletes. However, the influence the timing of initiation of these programs on the efficacy of ACL injury reduction has yet to be evaluated. **Objective**: To systematically review and synthesize the scientific literature in regards to the influence of age of NMT implementation on the effectiveness for reduction of ACL injury incidence. **Data Sources:** A computerized search was performed using PubMed, CINHAL, Health source, Medline, SPORT Discus, (1995-2010)in September, 2011. Key words were "anterior cruciate ligament," "ACL," "prospective," "neuromuscular," "training," "female," and "prevention ."Language was limited to English. Abstracts and unpublished data were excluded. **Study Selection:** Criteria for inclusion required that 1)number of ACL injuries were reported, 2)a NMT program was utilized, 3)females were included as participants, 4)studies used pro-spective, controlled trials, and 5)age of the participants to the program was documented or was reported by the corresponding author on follow-up contact. **Data Extraction:** Number of ACL injuries, the number of subjects and the age of participants for intervention and control groups were extracted. The age of participants (mean or ranged data) were analyzed with dichotomous categorization (≤18yrs vs >18yrs) and aggregated into tertiary categories of early adult(>20yrs), late teens(18-20yrs), or mid teens(14-18 yrs).A meta-analysis with odds ratio(OR) was used to compare a ratio of ACL injuries between intervention and control groups among differing age categorizations. **Data Synthesis:** Eleven of 528 studies were included. Results are presented as OR [95%Confidence Intervals]. The dichotomous analysis demonstrated statistically lower ACL injuries(OR 0.26: [0.16,0.43])in ≤18yrscompared to >18yrs(OR 0.81: [0.53,1.25]) group. The tertiary analysis indicated statistically lower ACL injuries in youngest age group(OR 0.26: [0.16, 0.43]) compared to late teens(OR 0.48: [0.21,1.07]) and early adult(OR 1.00: [0.59,1.70])participants undergoing NMT. **Conclusions:** The findings of this meta-analysis revealed an age related association between NMT implementation and reduction of ACL incidence. Both biomechanical and the current epidemiological data indicate that the potential window of opportunity for optimized ACL injury risk reduction may be prior to the onset of neuromuscular deficits and peak knee injury incidence in females. Specifically, it may be optimal to initiate integrative NMT programs during pre-adolescence, prior to the period of altered mechanics that increase injury risk.

Effects of Therapeutic Modalities on Altering Quadriceps Activation: A Systematic Review

Harkey MS, Gribble PA, Pietrosimone BG: The University of Toledo, Toledo, OH

Context: Neuromuscular alterations, such as decreased voluntary quadriceps activation, are commonly associated with multiple knee pathologies. Traditional rehabilitation often fails to address this neuromuscular impairment, leaving the joint susceptible to further injury. Recent research has been conducted to develop interventions to improve quadriceps activation, yet, partly due to a lack of knowledge regarding intervention efficacy, these therapeutic modalities have been slow to translate into clinical practice. Additionally, it remains unknown which modalities are most effective in improving voluntary quadriceps activation. **Objective**: To determine the magnitude of the effect of various therapeutic modalities on voluntary quadriceps activation. **Data Sources**: The Web of Science and PubMed databases were searched between the years of 1950 and 2011 with the keywords "quadriceps activation", "disinhibitory", and an exhaustive list of potential modalities. **Study Selection**: The initial search query included 9,319 studies. Studies that evaluated the implementation of a therapeutic modality on volitional quadriceps activation using the central activation ratio or the interpolated twitch testing methods were retained. Pertinent studies were cross-referenced for relevant articles, leaving 9 studies that met our inclusion criteria. **Data Extraction**: Voluntary quadriceps activation, expressed as a percentage of complete activation, was our main outcome measure. We extracted voluntary quadriceps activation means and standard deviations measured at baseline and at all available post-intervention time points. Studies were assigned a PEDro score, with

agreement from two investigators. **Data Synthesis**: The 9 studies (mean PEDro=6.8±0.8) were grouped into five categories based on the modalities that were evaluated including: manual therapy (3 studies), transcutaneous electrical nerve stimulation (TENS;2 studies), cryotherapy (2 studies), neuromuscular electrical nerve stimulation (NMES;2 studies), and transcranial magnetic stimulation (TMS;1 study). Cohen's effect sizes (*d*=posttest–pretest/pooled standard deviation) with 95% confidence intervals (CI) were calculated for each modality at all time points to allow for comparisons of immediate and sustained effects. TENS demonstrated the strongest immediate effects (*d*=1.03; 95% CI 0.06,1.92) at 45-minutes following initial application, as well as sustained strong and definitive effects at four weeks (*d*=1.81; 0.80,2.68) following a TENS and exercise intervention. NMES produced weak to strong effects (range *d*=0.20-1.87) over a period of three weeks to six months. Cryotherapy (*d*=0.5; -0.35,1.35) and TMS (*d*=0.54; -0.33,1.37) had moderate immediate effects for improved voluntary quadriceps activation, while manual therapy, particularly joint manipulations (*d*=0.38;-0.35,1.09) elicited only weak immediate effects. **Conclusions**: TENS demonstrated the greatest immediate and sustained effects in quadriceps activation, and may be the best current choice for improving quadriceps activation clinically. NMES produced a wide range of effects (weak–strong), which may limit current conclusions on the efficacy of this modality for improving quadriceps activation. More research needs to be compiled for TMS, cryotherapy, and manual therapy to determine the extent of the immediate and sustained effects.

Effect of Textured Insoles on Static Balance in Individuals with a History of Lateral Ankle Sprain

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Context: Textured insoles have been shown to improve postural control measurements in healthy individuals, however it is not clear if these improvements are seen in individuals with existing postural control deficits.**Objective:**To examine the effect of textured and non-textured insoles on static balance in individuals with a history of ankle sprains. **Design:** Single-blinded randomized controlled trial**Setting:** Laboratory. **Patients or Other Participants:** Twenty-two individuals (10 females, 12males, age=22.3±3.7years, height= 175.6± 11.5cm, mass=74.2±15.1kg) with a history of one or more lateral ankle sprains (mean number of ankle sprains within the last year=3.8±2.5). **Interventions:** A ¾ length textured insole with raised rubber nodules shaped to the contours of the foot and a smooth ¾ length insole made of 1.5mm thick closed cell foam served as the intervention and sham treatments, respectively.Following a 2 day accommodation period, subjects wore their prescribed insoles at least 6 hours per day for two weeks. **Main Outcome Measures:** The mean and standard deviation (SD) of the time to boundary (TTB) minima in the anteroposterior (AP) and mediolateral (ML) directions was assessed during 10 second trials of unilateral quiet stance while shod and with eyes open. Measurements were recorded at baseline, immediately following insole insertion, and at 2-week follow-up.For each measure, a 2x3 (groupby time) ANOVA with repeated measures was calculated. **Results:**There was no significant group by time interaction or group main effect for the SD of the TTBAP minima (p=0.79, p=0.70, respectively), however a significant time main effect (p=0.05) was observed indicating an improvement in static postural control at 2-week follow-up for both groups (textured: pre=9.2 ±2.6s, immediate=10.3±3.6s, 2-week= 10.8±3.1s; sham: pre= 8.7±3.3s, immediate=10.2±3.8s, 2-week= 9.8±3.1s). We did not observe any significant group by time interaction, group or time main effects for the mean of the TTBAP minima (p=0.30, p=0.47, p=0.08, respect-ively). There was no significant group by time interaction, group or time main effect for the mean of the TTBML minima (p=0.23, p=0.65, p=0.39, respectively) or the SD of the TTBML minima (p=0.37, p=0.85, p=0.33, respectively). Descriptive measures were as follows for the mean of the TTBAP minima (textured: pre=14.3 ±3.6s, immediate =16.7± 6.1s, 2-week= 17.2±5.2s; sham: pre=14.2± 5.5s, immediate =15.2± 4.3s, 2-week= 14.6±3.5s), the mean of the TTBML minima (textured: pre=5.2 ±1.2s, immediate=6.4±2.1s, 2-week=5.9± 1.6s; sham: pre=5.6± 1.9s, immediate =5.5±1.4s, 2-week= 5.6±1.4s), and the SD of the TTBML minima (textured: pre=4.0±1.4s, immediate=5.0±2.0s, 2-week= 4.4± 1.4s; sham: pre=4.4 ±1.6s, immediate =4.4±1.0s, 2-week= 4.1 ±1.2s). **Conclusions:**A 2-week textured insole intervention did not improve static balance in subjects with a history of ankle sprainsignificantly better than an untextured insole intervention. Improvements in TTBAP variability were observed in both groups, indicating a potential learning effect and the need for a true control conditionin future investigations.

Free Communications, Oral Presentations: Instructional Strategies in Athletic Training Education

Friday, June 29, 2012, 12:45PM-1:30PM, Room 260-267; Moderator: Andy Winterstein, PhD, ATC

Students' Perceptions of an Integrated Standardized Patient Program

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Context: Standardized patients (SPs) are used to teach and assess communication, clinical evaluation and clinical decision-making skills of students enrolled in health related programs. Little research exists examining the effectiveness of this pedagogical approach with Athletic Training (AT) students. **Objective**: To investigate AT students' perceptions of SPs and their benefit to developing/refining communication, history taking, physical assessment, and clinical diagnosis skills. **Design**: Cross-sectional. **Setting**: Research Laboratory. **Patients or Other Participants**: Forty-four undergraduate AT students (6 fourth-year, 14 third-year, 24 second-year) from a 4-year CAATE accredited Athletic Training Education Program (ATEP). **Interventions**: A SP program was integrated across the curriculum using theatre students and fourth-year AT students as trained SPs. AT students completed a clinical practice exam (CPE) involving a lower extremity injury presented by a SP. Theatre student SPs presented a 1° muscle strain case to second- and fourth-year students. Fourth-year student SPs presented a medial tibial stress syndrome case to third-year students. **Main Outcome Measures**: A Likert type scale (range 1-5; 5=strongly agree, 1=strongly disagree). Survey items assessed whether the SP case was realistic (#1); whether students perceived the SP experience beneficial for developing/refining history taking (#2), communication (#3), physical assessment (#4), and clinical diagnosis (#5) skills; whether students were confident in their clinical diagnosis (#6); and whether the SP case was appropriately challenging (#7). A Table of specifications (ToS) established content validity; a panel of experts established face validity. Descriptive statistics were used to analyze group responses to survey items. An ANOVA was used to determine group differ-ences between CPEs conducted with theatre and 4th year AT students. Levene's test assessed homogeneity of variance. All analyses were conducted with =.05. **Results**: The measures of the case being challenging and realistic were excluded due to significant a lack of homogeneity of variance pre- and post-transformation of the data. Overall, students agreed the SP experience was beneficial for developing/refining history taking (4.16 ± 0.834), communication (4.36 ± 0.685), physical assessment (4.23± 0.782), and clinical diagnosis (4.18 ± 0.922) skills. Seventy-five percent (n=33) of students strongly agreed (n=11) or agreed (n=22) that their SP case was appropriately challenging. Forty-seven percent (n=21) of students were confident in their clinical diagnosis of the SP case. AT students who had theatre students as SPs experienced greater confidence in their clinical diagnosis ($F(1,43) = 5.12$, p=.029). **Conclusions**: Our results support the use of SP in ATEPs. Overall, our findings suggest AT students perceive SPs to be beneficial in helping develop/refine clinical evaluation and patient communication skills.

Comparing Instructional Methods in the Knowledge Acquisition of Musculoskeletal Anatomy in Athletic Training Students

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Context: The importance and difficulty of teaching and learning musculo-skeletal anatomy has been documented previously. Little is recorded about the selection and implementation of instructional strategies to improve knowledge acquisition of anatomy in athletic training students (ATS). **Objective**: To compare the effect of traditional instructional methods (lecture, models, and charts) with traditional instructional methods plus a computer based instruction (CBI) simulation program on knowledge acquisition of musculoskeletal anatomy in undergraduate ATS. **Design**: A quasi-experimental, pre-test post-test counterbalanced comparison design. Participants were randomly assigned to one of two conditions. Group one received traditional instructional methods only for lower extremity course content and traditional instructional methods plus the CBI simulation for upper extremity course content. Group two participated in reverse order. **Setting**: A 3-credit undergraduate Anatomy and Physiology I course at a public university. **Participants**: A con-venience sample of 24 ATS was used. Students were eligible to participate if seeking a Bachelor of Science degree, and no prior university-level A&P coursework. A majority of participants (70.8%) were 19 years of age or younger and had earned 0-29 credits (77.1%). There were slightly more men (56.3%) than women (43.8%). **Interventions**: A CBI simulated cadaver dissection program consisting of dissection, animation, imaging, and self testing modules. **Main Outcome**

Measures: Student scores on pre and post-test upper and lower extremity multiple choice and practical examinations (split half correlation coefficient =.784). T-tests and repeated measures ANOVA with alpha levels of .05 were used to determine significant differences between the two conditions. **Results**: For the lower extremity there was a significant main effect for written and practical examination scores (F=263.24, P<.001) and a significant test score by intervention interaction (F=15.60, P<.001). Post hoc testing revealed that test scores were significantly greater (t=2.75, p=.012, ES=1.12) in the CBI group (M=36.67, SD=5.55) compared to the traditional group (M=30.67, SD=4.69).There were no significant differences in the pre-test scores (t=-.529, p=.602) between the CBI (M=19, SD=4.69) and traditional (M=19.92, SD=3.75) groups. For the upper extremity there was a significant main effect for written and practical examination scores (F=246.33, P<.001) and a significant test score by intervention interaction (F=196.02, P<.001). Post hoc testing revealed that test scores were significantly greater (t=3.17, P=.004, ES=1.29) in the CBI group (M=39, SD=3.16) compared to the traditional group (M=31.42, SD=7.66).There were no differences in the pre-test scores (t =-.219, P=.829) between the CBI (M=18.67, SD=4.4) and traditional (M=19.17, SD=6.59) groups. **Conclusions:** Both groups of participants had increases in pre-post test scores; however, participants utilizing traditional instructional methods plus CBI had greater post-test scores. The addition of a CBI simulated cadaver dissection improved knowledge acquisition of lower and upper extremity musculoskeletal anatomy in undergraduate ATS. Further work is needed to determine why this effect occurred.

Using StudyMate® and Online Flashcards in a CPR Course Does Not Improve Learning Outcomes or Retention

Berry DC, Berry LM: Saginaw Valley State University, University Center, MI

Context: Teaching strategies/activities such as games and puzzles can promote student interest in learning in different educational domains. However, these pedagogical tools have not examined the potential for student learning and retention in a cardiopulmonary resuscitation (CPR) and Automated External Defibrillation (AED) course. **Objective:** To examine the effectiveness of online flashcards and StudyMate® as pedagogical tools to improve learning outcomes and retention of cognitive knowledge related to CPR and AEDs. **Design:** Repeated measures. **Setting:** University classroom. **Participants:** Forty-seven undergraduate students (males=16, females=31; 20.15±2.8 years of age) enrolled in two CPR for the Professional Rescuer courses taught by the same instructor participated in the study. **Interventions:** Students in each class were randomly assigned to three groups; control (n=15), online flashcards (n=15) and StudyMate® (n=17). One-hundred and forty six terms/concepts related to CPR and AEDs considered important by the instructor were used to construct the StudyMate® (Respondus, Inc.) and online flashcards (Flashcard Exchange©, Tuolumne Technology Group; http://www.flashcardexchange. com). Students in both treatment groups were asked to spend a minimum of 60 minutes studying with their pedagogical tool one week prior to the post-test. The control group received no access to neither program and was asked to prepare for the midterm using their own study habits. Each group received identical course information. Repeated measures of analysis of variance (ANOVA) with between-subjects (group) and within-subjects (time) effects assessed pre, post, and follow-up exam scores. **Main Outcome Measures:** The average of two American Red Cross exams; 1) CPR exam and 2) AED exam was used to calculate a combined exam score administered at three time intervals; pre, post and 6 weeks follow-up. **Results:** Pre-test combined exam scores for the control, online flashcard, StudyMate® groups were 57.97±11.23, 61.20±12.81 and 63.59±16.37 respectively. Post-test combined exam scores for the control, online flashcard, StudyMate® groups were 82.80±7.74, 84.76.20±9.64 and 87.32 ±8.36 respectively. Six week follow-up combined exam scores for the control, online flashcard, StudyMate® groups were 83.60±8.57, 88.00±8.56 and 87.59 ±7.33 respectively. A repeated measures ANOVA with a Huynh Feldt correction revealed a significant main effect for time ($F_{1.69,74.6}$= 131.56, P < 0.001) on exam scores. All groups increased their examination scores from pre (60.92±2.01 SE) to post (84.96±1.25 SE) and follow-up (86.40±1.19 SE). Results revealed no significant interaction or group main effect. **Conclusions:** The results of the study indicated that the use StudyMate® and online flashcards in a CPR for the Professional Rescuer course as pedagogical tools does not improve overall exam scores compared to traditional methods of studying (control). Further research is necessary to examine the effects of StudyMate® and online flashcard for student test performance as well as examine students' perceptions and preferences for these pedagogical tool as learning activities.

Perceptions of Female Athletic Training Students on Motherhood in the Division I Clinical Setting

Gavin KE: Mazerolle SM.Villanova University, Philadelphia, PA; University of Connecticut, Storrs, CT

Context: Attrition issues, particularly of female athletic trainers, have been a concern for the profession of athletic training. Motherhood appears to play a catalyst in turnover for the female, especially if employed at the Division I College level. A majority of the literature examining this topic however examines the perspectives of those employed rather than those who are preparing to enter the profession. **Objective:** The purpose of this study was to evaluate perceptions of motherhood and retention in athletic training from the student. **Design:**Structured, online asyn-chronous interviews. **Setting:** Commission on Accredited Athletic Training Education (CAATE) Programs in the Division I setting. **Patients or Other Participants:**Eighteen female athletic training students (sophomores =5; juniors=6; seniors =7) volun-teered. Average age of the participants was 21±1. All were full-time students who were taking a full-academic load in athletic training, which included a clinical practicum experience. **Data Collection and Analysis:** Participants responded to a series of questions by journaling their thoughts and experiences. Participant checks and peer review were included as steps to establish data credibility. The data was analyzed borrowing from the principles of general inductive approach. **Results:**The first theme *clinical setting*, speaks to the participant's beliefs that work life balance and retention in athletic training requires an employment setting, which fosters a family-friendly atmosphere and a work schedule, including travel that allows for more time at home. The second theme, *mentorship* reflects the participant's acknowledgement that a female mentor who is successful balancing the roles of mother and athletic trainer, would impact their ability to follow their lead. The final theme, *work life balance strategies* illustrates the participant's discussion of the need to have a plan in place to meet the demands of both home and work life.**Conclusions:**Comparable to other research it appears as though clinical setting, particularly the secondary school level, is perceived to provide a more suitable work environment for the female athletic trainer. Our results also coincide with research, which identifies that working professionals work life balance priorities lie with employment arrangements, such as flexibility and hours worked, as well as parenting responsibilities, which includes childcare responsibilities. As more female professionals, such as this cohort of young, continue to stay optimistic and believe they can balance both roles successfully without sacrificing one over the other, it is conceivable for athletic training to be a viable profession that includes mothers. Mentorship was one of the most valuable tools for persistence in the profession; future investigations should evaluate the direct influence of those female students who have had a female mentor with children as this cohort was deficient in this experience as only a few were able to directly work alongside a female athletic trainer with a family.

Likelihood of High Burnout Among Certified Athletic Trainers in Various Job Settings

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Context: Athletic Trainers work in a wide variety of job settings and depending on the job setting may be at a higher risk for job burnout. The investigation of the relationship between job setting and level of burnout may produce interventions to reduce setting specific factors that cause job burnout and reduce the dangers of having a medical professional experience burnout while working with patients. **Objective:** To determine the difference in burnout scores relating to setting in District 9 (SEATA) of the NATA. **Design:** A cross sectional web-based survey design determined whether levels of burnout differ between athletic trainers who work in upper colleges (Division I and II), high schools, and clinical settings (physical therapy or hospital clinics). **Setting:** District 9 of the National Athletic Trainers' Association (NATA) **Participants:** Convenience sample of athletic trainers listed in the SEATA district or District 9 mailing list (n=1560) (128=college, 139=high school, 70=clinic). **Interventions:** Subjects completed demographic questions (hours worked per week, year's experience, and gender) and the 12-item Copenhagen Burnout Inventory (CBI) through an online survey. Permission was obtained and the CBI is valid and reliable (Kristenson 2005). **Main Outcome Measures:** Burnout scores were calculated from the 3 subsections (work, personal and client) of the CBI. A corresponding CBI burnout score of greater than 50 is considered high burnout. **Results:** A one-way ANOVA showed that a significant difference between burnout levels occurs among settings (p=.001),

with college (M=43.32±16.88) and high school (M=44.47±16.53). Athletic trainers reporting higher burnout than clinic athletic trainers (M=35.22 ±18.39). Logistic regression indicated that after controlling for gender, year's experience, hours worked, and age, college athletic trainers were 2.24 times more likely to report a high level of burnout (score >50) compared to clinic athletic trainers [p=.046, odds ratio (OR): 2.24, 95% confidence interval (CI): 1.02-4.94]. Additionally, high school athletic trainers were 3.15 times more likely to report a high level of burnout compared to clinic athletic trainers [p=.004, odds ratio (OR): 3.15, 95% confidence interval (CI): 1.47-6.86].**Conclusions:** Based on these results, the setting of employment is a possible factor related to burnout in athletic trainers. More specifically, athletic trainers working in high level colleges and high school settings are more likely to experience a high level of burnout compared to those working in clinic settings. Future research should expand beyond District 9 and include more levels of job settings like industrial setting athletic trainers and all the levels of college sports (D I, II, III).

Employers' Knowledge and Confidence Concerning Athletic Training Education Programs: A Descriptive Study

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Context: Identifying employers' current knowledge of athletic training education programs (ATEPs) is essential before researchers can accurately investigate the qualifications, attributes, and types of experience employers prefer their employees to possess. **Objective:** To assess employers' perceived knowledge (PK), objective knowledge (OKn), and confidence in their knowledge (CIK) regarding various ATEPs. **Design:** Cross-sectional descriptive survey. **Setting:** Web-based survey. **Patients or Other Participants:** Fifty-eight of 171 employers (33.9% response rate) from a convenience sample from the NATA public vacancy notice (37 males, 21 females age=42.67±9.35) (38 clinicians, 13 educators, and 7 administrators) participated in the study. **Interventions:** Participants were sent an e-mail asking them to complete the online survey consisting of: (1) five, 4-point Likert scale items assessing PK of professional ATEPs, professional master's ATEPs, and post-professional ATEPs (PPATEPs); (2) thirteen multiple-choice questions to assess OKn; (3) thirteen 4-point Likert scale items to assess CIK for each OKn question. Reliability from an unrelated pilot sample (n=13) for the OKn section was determined to be excellent; percent agreement averaged 96% with a range of 83.33%-100%. **Main Outcome Measures:** OKn scores were tabulated by awarding 1 point for each correct answer with a maximum score of 13. OKn subsection scores were also created for all questions pertaining to OKn of professional ATEPs (6 questions), professional master's ATEPs (7 questions), and PPATEPs (7 questions). Some OKn questions assessed knowledge of both professional and professional master's ATEPs and were awarded 1 point within each subsection. PK and CIK scores were achieved by totaling all values and then calculating the average value back to the Likert composite score (total divided by 4). A higher score indicated the participant had a higher perceived knowledge or higher confidence in their responses to the OKn questions. Means and standard deviations were calculated for all responses; 95% confidence intervals (CI) were calculated for OKn scores. **Results:** Participants' PK scores indicated they perceived themselves as "moderately knowledgeable" of ATEPs (3.04/4.0±0.70). Overall OKn scores were 8.47±2.64 (95%CI=7.77-9.16), while overall CIK scores (3.21/4.0±0.68) indicated participants were "moderately confident" in their OKn responses. Employers achieved the highest OKn (4.83±1.48, 95%CI= 4.44-5.22) and CIK (3.21/4.0±0.68) scores on questions regarding professional ATEPs. Educators achieved the highest OKn scores (10.85±1.77, 95%CI=9.76-11.92) and also reported the highest overall CIK scores indicating they were "extremely confident" (3.72/4.0 ±0.36). **Conclusions:** The primary finding of this study is that employers are only moderately familiar with differences between ATEPs. Employers are familiar with desired hiring characteristics and criteria, but their limited knowledge regarding the differences between ATEPs indicates they do not fully comprehend which programs exemplify these qualifications. While future research should involve a larger sample size of employers, it is necessary to educate employers about the qualifications of graduates from differing programs.

Reliability and Validity of an Instrument Identifying the Predictors of Career Intent Among Athletic Trainers

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Context: Little is known as to what predicts an athletic trainer's (AT's) intent to stay in a position, a setting, or the entire AT profession (i.e., career intent). Currently, no instrument is available to measure AT career intent. **Objective:** To develop an instrument identifying the variables that predict AT career intent in order to evaluate the fit of an established turnover model in AT. **Design:** Descriptive study. **Setting:** All AT professional settings nation-wide. **Patients or Other Participants:** Instrument design experts and experts in 8 AT professional settings participated in face (n = 6) and content validity (n = 11) testing. ATs employed in full-time AT positions participated in pilot testing: Pilot test 1 (n = 47) and pilot test 2 (n = 150). **Main Outcome Measure(s):** We created the Athletic

Training Career Intent Survey (ATCIS) from previous instruments used to test the Price-Mueller model of turnover in other health care fields (e.g., nursing and physicians). Our initial ATCIS measured career intent and 18 individual, environmental and job structure variables. The survey contained 23 demographic and 108 career intent items. We conducted 2 field tests to assess face and content validity, and reliability analyses on 2 separate on-line survey pilot tests using a Cronbach set a priori at 0.80 and item-to-total correlations. We also performed an exploratory factor analysis on pilot test 2 to evaluate construct validity. **Results:** Our first field test demonstrated face validity with minor changes. In our second field test for content validity, items averaging below 5.7 on a 7-point Likert scale of item-appropriateness were discarded or modified. The Cronbach's Alpha coefficient for pilot test 1 was = 0.793 (77 items). We then removed or modified items with negative or low (< 0.3) item-total correlations. The initial Cronbach's Alpha coefficient for pilot test 2 was = 0.922 (62 items). Removal of low items improved the Alpha (= 0.936; 45 items). The exploratory factor analysis revealed the presence of 4 components accounting for 51% of the variance. These 4 components included career/job engagement (30.1%), supervisory support (8.4%), pay and promotion (6.6%) and co-worker support (5.9%), and reduced the ATCIS to 40 career intent items measuring 14 variables. **Conclusions:** Creation of the ATCIS is an important first step in understanding ATs' intent stay in or leave a certain position, a certain setting, or the entire profession. We subjected the ATCIS to rigorous testing and demonstrate it to be both valid and highly reliable. Future ATCIS research should include larger samples to evaluate these predictors of AT career intent. Longitudinal studies incorporating the ATCIS could assist in establishing a model of AT turnover.

Bilateral Comparison of Shoulder Kinematics in Collegiate Volleyball Players

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Context: Changes to the shoulder complex, such as postural impairment, muscle length and scapular dyskinesis, have been associated with shoulder injuries in overhead athletes. It is unknown if some amount of change in shoulder kinematics is normal as a result of participating in an overhead sport regardless of the presence of shoulder injury. **Objective:** To compare bilateral scapular upward rotation, anterior scapular position, glenohumeral internal rotation and glenohumeral external rotation in healthy elite volleyball players prior to pre-season. **Design:** Within subject. **Setting:** Controlled laboratory environment. **Patients or Other Participants:** Fifteen female collegiate volleyball athletes (19.0± 1.2 y, 175.4±5.5 cm, 71.5±9.2 kg) with no history of shoulder injury participated in this study. **Interventions:** Static scapular upward rotation was measured at rest, 60°, 90° and 120° of humeral elevation in the scapular plane with an electrical inclinometer. Anterior scapular position was measured using the pectoralis minor length test. While the subject laid in a supine position, the distance in centimeters from the table to the posterior aspect of the acromion process was measured with a modified triangle. For glenohumeral internal rotation and external rotation, subjects laid in a supine position with the shoulder abducted to 90 and the elbow flexed to 90°. Maximum passive glenohumeral internal rotation and glenohumeral external rotation were measured with a digital protractor placed in-line with the olecranon process and ulnar styloid process. Three trials were performed on the dominant and non-dominant arms for all measurements. The average of the three trials for each measurement was calculated. The side and order of measurements were randomized. The independent variable was side (dominant and non-dominant). **Main Outcome Measures:** The dependant variables were the bilateral mean measurements for scapular upward rotation at rest, 60°, 90° and 120°, anterior scapular position, gleno-humeral internal rotation and glenohumeral external rotation. The influence of side for each dependent variable was compared using paired samples t-tests with an adjusted alpha level ($p<0.007$). **Results:** Statistical analysis revealed anterior scapular position ($t_{14}=3.646$; $p=0.003$) was significantly greater on the dominant side (5.9±1.1cm) compared to the non-dominant side (5.0±1.2cm). Gleno-humeral internal rotation ($t_{14}= -3.689$; $p=0.002$) was significantly greater on the non-dominant side (74.6±7.2°) compared to the dominant side (66.2± 8.2°). There were no significant differences for gleno-humeral external rotation ($t_{14}= 1.212$; $p=0.245$) or scapular upward rotation at rest ($t_{14}=1.417$; $p=0.178$), 60 ($t_{14}=0.075$; $p=0.942$), 90 ($t_{14}=-0.205$; $p=0.840$) and 120 ($t_{14}=0.590$; $p= 0.564$). **Conclusions:** Bilateral differences in anterior scapular position and glenohumeral internal rotation were evident. Measurements were taken on healthy participants prior to pre-season. It is possible these kinematic differences are normal adaptations associated with participation in an overhead sport or precursors to shoulder injury. A longitudinal study where shoulder kinematics of overhead athletes are tracked over the course of a season is warranted.

Hip Range of Motion Predicts Dynamic Lower Extremity Alignment in Adolescent Athletes

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Context: ACL injuries are increasing in adolescent athletes, while the factors that increase risk of injury remain unknown. Differences in hip rotation range of motion (ROM) have been theorized to contribute to dynamic alignments known to increase the risk of ACL injury. While this relationship has been observed in the adult population, there is little research investigating the influence of hip ROM on dynamic joint angles in the adolescent athlete. **Objective**: To determine the influence of hip ROM on frontal and transverse plane hip and knee joint angles during a double-leg jump landing (JL) task in adolescent athletes. **Design**: Cross-Sectional. **Setting**: High school athlete screening. **Patients or Other Participants**: Forty seven male (15.6±1.2yrs, 178.3±8.6cm, 72.1± 11.7kg) and twenty six female (16.0±1.1yrs, 166.2±9.0cm, 60.3± 9.0kg) adolescent athletes volunteered as part of a larger, multi-center risk factor screening project. **Interventions**: Hip internal (HIR) and hip external (HER) rotation range of motion were measured with a digital inclinometer during three trials on the dominant limb by a clinician with known reliability ($ICC_{2,k}>0.85$). The JL task required participants to jump forward from a 30cm height at a distance of half their body height and perform a maximal vertical jump upon landing. A three-dimensional motion analysis system assessed hip and knee kinematics during three JL trials on the dominant limb. **Main Outcome Measures**: Frontal and transverse

plane hip and knee joint angles were extracted at initial contact (GRF≥10N) and joint excursions were calculated by subtracting the initial contact joint angle from the peak angle determined during the deceleration phase (initial contact to peak knee flexion) of the JL task. Average hip ROM over each of the three measurements and average joint angles over the three JL trials were calculated for analyses. Separate step-wise linear regressions were performed to determine the extent to which the hip ROM measures predicted frontal and transverse plane hip and knee joint angles in males and females. **Results**: In males, more HER (35.3±9.5°) predicted more knee valgus angle at initial contact (-4.5±5.0°) explaining 8.6% of the variance (P=0.046). In females, more HER (31.3±9.7°) predicted less knee valgus at initial contact (-6.3±3.7°; R^2=0.253, P=0.009), less knee valgus excursion (-6.5±5.6°; R^2=0.267, P=0.006), and less knee external rotation excursion (-8.4±6.7°; R^2= 0.219, P=0.016) during the JL task. **Conclusions**: Decreases in hip external range of motion influence knee joint angles and motions during a JL task. This may in part be due to the changes in the length-tension relationship of the surrounding muscles, which can lead to dynamic mal-alignments known to be predictive of ACL injury. Ongoing research will examine whether these range of motion differences increase the risk of ACL injury in adolescent athletes. *Supported by University of North Florida Faculty Development Research Grant*

A Comparison of Functional Movement Screen™ and Star Excursion Balance Test Performance Among Female Collegiate Athletes

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Context: Previous investigations suggest performance on the Functional Movement Screen (FMS™) and Star Excursion Balance Test (SEBT) may provide predictive capabilities for acute lower extremity injury in selected male athletes, but little information exists to establish the effectiveness of acute injury prediction among female collegiate athletes. Furthermore, it is unknown if published baseline scores of these two performance tests should be the standard for collegiate female athletes, specifically those participating in basketball, soccer, and volleyball. **Objective:** To determine if baseline scores for FMS™ and SEBT are similar for female collegiate athletes participating in basketball, soccer and volleyball. **Design:** Cohort. **Setting:** Athletic training clinic. **Patients or Other Participants:** Fifty-four Division I women's collegiate athletes from basketball (N=14; 19.71± 1.54yrs, 179.43±7.16cm, 73.39± 14.80kg), soccer (N=24; 19.33± 1.20yrs, 166.69±4.78cm, 60.97± 5.53kg), and volleyball (N=16; 19.38 ±1.15yrs, 179.10±7.14cm, 70.99±6.92kg) teams volunteered. **Interventions:** Prior to their 2011 respective seasons, all participants performed all seven stations of the FMS™ (deep squat, hurdle step, in-line lunge, shoulder mobility, active straight leg raise, trunk stability push-up, and rotary stability); and the anterior, posteriormedial, and posteriorlateral directions of the SEBT, assessed bilaterally. **Main Outcome Measures:** Each station of the FMS™ is scored on a 0-3 scale, with a total possible composite score of 21 points indicating a perfect performance. In each SEBT reach direction, the average of three trials were recorded in centimeters and expressed as a percentage of the stance limb length (%MAXD). The left and right sides were not statistically different for any of the directions, so the performance scores were averaged for the two sides for each athlete and used for further analysis. The three %MAXD values (anterior, posteriormedial, posterior-lateral) were averaged to create a composite reach score One-way ANOVAs were performed to compare mean composite scores across sports, with LSD post-hoc testing applied. Effect sizes (Cohen's d) with 95% confidence intervals (CI) were calculated using pooled standard deviations. Signi-ficance was set at P≤0.05. **Results:** A significant difference was observed between sports for the FMS ($F_{2,51}$=3.46, P=0.039) and SEBT ($F_{2,51}$=3.46, P=0.045) composite scores. Post hoc testing supported that, for the FMS, soccer players (17.21 ±1.72) scored higher than basketball (15.64±2.56; LSD=0.025; d=0.76, 95%CI: 0.06, 1.42) and volleyball players (15.88 ±1.89; LSD=0.045; d=0.75, 95% CI:0.08, 1.38). Similar-ly, for the SEBT composite score, soccer players (83.68±6.34%) scored higher than basketball (78.60±8.46%; LSD= 0.031; d=0.71, 95%CI: 0.02, 1.38) and volleyball players (79.15 ±5.90%; LSD=0.045; d=0.73, 95%CI: 0.06, 1.37). **Conclusion:** Female soccer players scored better on the FMS™ and SEBT compared with basketball and volleyball players. Additionally, these scores vary from published pre-season assessments of other athletes and sex, suggesting different standardized comparison scores may be needed for different sports and genders. Clinicians are encouraged to utilize specific scoring standards that will help to identify and treat potential injury among athletes.

Relationship Between Static Lower Extremity Alignment and Landing Mechanics in Adolescent Athletes

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Context: It is theorized that abnormal static lower extremity alignment (LEA) may contribute to dynamic malalignments known to increase the risk of knee injuries. Limited research exists examining the relationship between LEA and dynamic joint motions; particularly during functional tasks observed to increase injury. Moreover, limited research has examined these relationships in the adolescent athlete where early detection of risk factors and subsequent preventative measures may be beneficial. **Objective:** To determine the influence of static LEA on frontal and transverse plane hip and knee joint angles during a double-leg jump landing (JL) in adolescent athletes. **Design:** Cross-Sectional. **Setting:** High school athlete screening. **Patients or Other Participants:** Forty-five male (15.6±1.3yrs, 178.0±8.4cm, 72.0± 11.7kg) and twenty-four female (15.9±1.1yrs, 165.7±8.4cm, 59.7± 9.1kg) adolescent athletes volunteered as part of a larger, multi-center risk factor screening project. **Interventions:** Clinical measures of pelvic angle (PA), genu recurvatum (GR), and navicular drop (ND) were measured on the dominant limb by a clinician with known reliability ($ICC_{2,k}$>0.87). Tibiofemoral angle (TFA) and Q-angle (QA) were assessed using an electromagnetic tracking system. The JL task consisted of landing on a force plate from a height of 30cm and rebounding vertically for maximum height. A three-dimensional motion analysis system was used to assess hip and knee kinematics during three JL trials on the dominant limb. **Main Outcome Measures:** Frontal and transverse plane hip and knee joint angles were extracted at initial contact (GRF≥10N) and joint excursions were calculated by subtracting the initial contact joint angle from the peak angle determined during the deceleration phase (initial contact to peak knee flexion) of the JL task. LEA values were averaged over the three measurements and joint angles were averaged over the three JL trials. Separate step-wise linear regressions determined the extent to which static LEA predicted frontal and transverse plane hip and knee joint angles for males and females. **Results:** In males, greater GR (0.21±2.0°, R^2=0.143, P=.010) and greater QA (12.5±11.5°, R^2_{change} =0.102, P=.022) combined to predict greater knee valgus excursion (-8.9±6.4°) explaining 24.5% of the variance (P=0.003). Greater ND (6.7±4.0°) in males predicted less hip adduction at initial contact (-5.2±6.0°, R^2=0.09, P=.045) but greater hip adduction excursion (10.8±6.7°, R^2=0.112, P=0.026). In females, less PA (10.9±4.5°) predicted greater hip internal rotation excursion (10.8± 7.2°, R^2=0.187, P=0.035). **Conclusions:** Static LEA appears to be associated with hip and knee joint angles during a JL task. However, the relationships were relatively weak with 75% of the variance left unexplained. These findings suggest that static LEA alone may not contribute to differences in lower extremity kinematics during landing tasks. Ongoing research will examine the role of other neuro-muscular and anatomical factors that may influence joint kinematics during functional tasks in adolescents. *Supported by University of North Florida Faculty Development Research Grant.*

Performance Technology: Effects of EFX® on Static & Dynamic Balance

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Context: The popularity of "wearable" performance technology continues to grow in athletic arenas and the general community. These items, commonly marketed as silicone bracelets and necklaces, are touted to improve physical performance. **Objective**: To examine the effects of a commercial sporting goods accessory, EFX® (www.efxusa.com), on static (S) and dynamic (D) balance. **Design**: Two separate studies are presented (S) & (D), both utilizing double blinded crossover study. **Setting**: Research laboratory. **Patients or Other Participants**: All subjects presented with no current or recent history of lower extremity injury or neural cognitive impairment. (S) 25 participants (males = 9, females = 16) (age = 21.8 ±2.6 years, mass = 66.9 ±13.6 kg, height = 167.6 ±8.9 cm). (D) 30 participants (males = 17, females = 13) (age = 21.9 ±3.1 years, mass = 73.2 ±16.0 kg, height = 170.9 ±8.1 cm). **Interventions**: EFX® is a readily available commercial product that contains a plastic holographic dot. For both studies the independent variable was treatment condition: activated dot (EFX), non-activated dot (XFE), and no dot (CO). The order of treatment condition was randomized for each subject. The subject and test administrator were blinded to the order of the treatment conditions. (S) Participants completed one testing session consisting of a static balance task under the three conditions. Participants were instructed to stand on their dominant leg for 15 seconds and remain as still as possible. A force platform (AMTI, Inc., Watertown, MA) was used to assess static balance at a sample rate of 1500 Hz. (D) Participants completed one testing session consisting of a dynamic balance task under the three conditions. A Y-Balance Test Kit

(Perform Better, Cranston, RI) was used to assess dynamic balance. **Main Outcome Measures**: Dependent variables for: (S) total range (mm) of Center of Pressure in the frontal (COPX) and sagittal (COPY) planes; (D) reach distance (cm) in different directions (anterior, posterior, lateral). An ANOVA with repeated measures was used to assess differences between treatment conditions for each study. **Results**: (S) No differences between treatment conditions (mean ±SD) occurred for Center of Pressure: COPX (EFX 29.02 ±4.2, XFE 30.13 ±6.6, CO 29.93 ±6.2, $P = .622$), COPY (EFX 39.11 ±5.9, XFE 40.04 ±10.4, CO 38.43 ±9.0, $P = .672$); (D) No differences between treatment conditions (mean ±SD) occurred for balance: Anterior (EFX 59.16 ±7.0, XFE 58.43 ±7.1, CO 59.33 ±6.7, $P = .256$), Posterior (EFX 73.88 ±10.1, XFE 73.47 ±10.3, CO 74.02 ±9.5, $P = .791$), and Lateral (EFX 70.49 ±9.5, XFE 69.79 ±8.8, CO 70.39 ±8.3, $P = .678$). **Conclusions**: Our results indicate balance, static and dynamic, is not improved with EFX®. These findings do not support anecdotal claims provided by manufacturers, client testimonials, and marketing materials.

Effect of Implement Assisted Soft Tissue Mobilization on Iliotibial Band Tightness

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Context: The iliotibial band is a common site of fascial restriction in the lower extremity. Implement assisted soft tissue mobilization (IASTM) techniques have been created to ease the stress on clinicians' hands while reducing fascial adhesions. **Objective:** To determine if two IASTM techniques, specifically Graston Technique® and Gua Sha, influence iliotibial band flexibility. **Design:** Randomized controlled clinical trial. **Setting:** Research laboratory. **Patients or Other Participants:** Sixty physically active college students (age 20.7± 2.4 years, height 173.6±9.4 cm, mass 73.0±13.0 kg, 37 male, 23 female) with no history of IT band syndrome or patellofemoral pain syndrome volunteered to participate in this study. Subjects were required to have restricted hip adduction range of motion of 26º or less. **Interventions:** Subjects participated in 4 testing days, each 48-72 hours apart. Subjects were randomly assigned to one of three treatment groups: Gua Sha (GS), Graston Technique®(GT), and a control/sham group. On each day, subjects received the treatment specific to their group assignment. The GT group (n=20) received an IT band specific protocol consisting of an active warm-up, IASTM using the GT instruments, strengthening exercise, stretching, and cryotherapy per recommended protocol. The GS group (n=20) was treated with uni-directional stroking over the treatment area with a Gua Sha tool per recommended protocol. The control group (n=20) received an 8 minute sham microcurrent treatment. Hip adduction was measured using the Ober's test on 5 occasions: prior to any treatment (baseline) and following each treatment on days 1, 2, 3, 4. Three trials of the hip adduction test were completed during each test period and the average was used for statistical analysis. A repeated measures ANOVA with 1 within-subjects factor (test at 5 levels [baseline, day 1, day 2, day 3, day 4]) and 1 between-subjects factor (group at 3 levels [GT, GS, control]). Bonferroni post-hoc testing was conducted on any significant findings with *a priori* alpha level $P<.05$. **Main Outcome Measures:** Leg hip adduction(p) was measured using an Acumar Digital Inclinometer (Lafayette Instrument Company, Lafayette, IN) during a modified Ober's test. **Results:** A significant test by group interaction was identified ($F_{8,228}= 2.12$, p=0.03). Specifically, the Graston Technique® group had improved range of motion after each day of treatment (baseline= 20.2°± 0.9°, Day 4=27.0° ± 1.1°). The Gua Sha group also had improved range of motion after treatment on days 2, 3, and 4(baseline=20.0°±0.9°, Day 4=23.6° ± 1.1°). No changes in range of motion were identified between the test days of the control group (baseline=20.4°±0.9°, Day 4=22.4° ± 1.1°). **Conclusions:** Significant improvements in hip adduction range of motion occurred for both the Graston Technique® group and Gua Sha group; however the Graston Technique® group demonstrated greater magnitude of improvement over the test period.

Evaluating Concussion-Related Symptom Characteristics Using the Theory of Unpleasant Symptoms

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Context: Self-reported symptoms are currently the focus of concussion diagnosis and management. Research has identified the 22 most common concussion-related symptoms that only measure the severity of the symptoms. The Theory of Unpleasant Symptoms (TUS), developed from nursing literature, has identified symptoms to have four characteristics: frequency, severity, bothersomeness, and affect. Evaluating concussion-related symp-toms using the TUS may provide useful information on symptoms and their management. **Objective**: Using three of the four measureable characteristics (frequency, severity, and bothersomeness) based on the TUS to determine the relationship of self-reported concussion symptoms. **Design**: Observational design. **Setting**: Athletic Training Facility. **Patients or Other Participants**: Thirteen participants volunteered for this study (4 females, 9 males) with a mean age of 19.7 ± 0.9 years. All participants were active members of a collegiate division I, III, or club sport team. **Interventions**: A self-reported symptom assessment was developed using the TUS for the 22 common concussion-related symptoms that evaluate frequency, severity, and bothersomeness. The characteristics were adopted from symptom scales currently used to measure other chronic diseases. Frequency was measured on a 4-point likert scale from never to always. Severity was measured on a 3-point likert scale from not at

all to a great deal. Bothersomeness was measured on a 5-point likert scale from not at all to extremely. The characteristic affect was not measured because it is too highly personalized. Participants completed the symptom assessment immediately following the initial injury until the patient became asymptomatic (up to four days post injury). **Main Outcome Measures**: The dependent variables were the total scores for each of the three symptom characteristics. The relationships of the three characteristics were evaluated with correlations. Significance was set a priori at alpha level <0.05. Descriptive statistics for symptom characteristic totals for the first four days following the injury were calculated. **Results**: The characteristics severity and bothersomeness (r=0.93; P<0.05) and severity and symptom frequency (r=0.94; P<0.05) were highly correlated. The characteristics frequency and bothersomeness were also highly correlated (r=0.98; P<0.05). The mean symptom totals for frequency over four days were 20.5±9.2, 10.3±8.2, 9.2±6.3, and 7.8±5.1. The mean symptom totals for severity over four days were 14.0±6.5, 6.3±6.1, 7.2±7.0, and 4.8±4.7. The mean symptom totals for bothersomeness over four days were 23.1±11.8, 10.3±10.2, 7.2±7.3 and 6.6±5.3. **Conclusions**: The three measurable symptom characteristics were highly related providing no unique additional information. It is important to note that these results are only based on immediately following an injury and in the early stages of recovery (first four days). The TUS may provide more useful information for the long-term concussion management cases. Additional research in the acute phase is warranted to better understand symptom load.

The Relationships Between High and Low Symptom Responders on ImPACT and NeuroCom Scores

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Context: Computerized neuropsychological testing, postural stability testing and self-reported symptomology are all used in a comprehensive concussion assessment plan. Few studies have looked at the clinical relevance between high and low symptom responders and their performance on a neuropsychological and postural balance assessment. **Objective**: To determine the relationships between ImPACT and the NeuroCom sensory organization test (SOT) and self-reported symptomology at 24-hours post-concussion. **Design**: Cross sectional study from 2004 - 2011. **Setting**: Research laboratory. **Patients or Other Participants**: 119 collegiate athletes diagnosed with a concussion (80 male, 39 female): age 20.34 ± 1.44 years. **Interventions**: All participants were evaluated approximately 24 hours post-concussion on the ImPACT neuropsychological test, NeuroCom postural stability assessment using the SOT and Head Injury Scale (HIS) to assess self-reported symptomology. The HIS consists of 22 symptoms, which assess symptom duration (1-6 rating scale) and symptom severity (0-6 rating scale). Low responders were defined as approximately the lower 25% of duration scores (≤12) and severity scores (≤11). Whereas, high responders were defined as approximately the upper 25% of duration scores (≥30) and severity scores (≥33). Significance was set a priori at P<.05. **Main Outcome Measures**: Twenty-two self-reported symptoms ranked in severity and duration; mean stability and the SOT sub scores of somatosensory, visual, vestibular and visual conflict scores from the SOT, and the ImPACT composite scores for verbal and visual memory, visual motor and reaction time. **Results**: High responders for symptom severity (n=26) had significantly declined scores in verbal memory ($F_{1,55}$=7.27; P=.009), visual memory ($F_{1,55}$ =4.42; P=.040), reaction time($F_{1,55}$=6.00; P=.018), SOT mean stability($F_{1,51}$=6.71; P=.012), and SOT visual ($F_{1,51}$=8.79; P=.005) compared to low responders (n=31). Mean time to become self-report symptom free was 12.50 ± 7.4 days for high severity responders and 8.70 ± 5.3 days for low responders. High responders for symptom duration (n=27) had significantly declined verbal memory ($F_{1,52}$=5.83; P=.019), visual memory ($F_{1,52}$=4.09; P=.048), reaction time ($F_{1,52}$=8.22; P=.006), SOT mean stability ($F_{1,45}$=6.10; P=.017), and SOT visual ($F_{1,45}$=5.13; P=.028) scores compared to low responders (n=27). Mean time to become self-report symptom free was 12.83 ± 7.2 days for high duration responders and 8.29 ± 5.2 days for low responders. **Conclusions**: Our results show that high symptom responders demonstrated a significant decline in ImPACT and NeuroCom scores compared to low symptom responders, in the first 24 hours post-concussion. While this is not an unexpected finding, our data demonstrates that those with a greater symptom response were more impaired on typical measures used for concussion assessment. Further, those who had higher self-report symptoms tended to take more time until symptom-free. While self-report symptoms are one part of a comprehensive concussion management plan, we advocate a multi-faceted approach to include neuropsychological testing and postural stability assessment.

Does Severity of a Previous Lower Extremity Injury Influence Health-Related Quality of Life?

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Context: Evaluation of health-related quality of life (HRQOL), through the use of patient-rated outcome measures (PROMs), ensures comprehensive patient care. While the literature suggests that sport-related injury impacts both physical and mental domains of HRQOL, few have studied whether previous history of injury results in a long-term impact on HRQOL. **Objective:** To determine whether severity of a previous lower extremity (LE) injury impacts the HRQOL of collegiate athletes. **Design:** Cross-sectional. **Setting:** Athletic training facilities. **Patients or Other Participants:** Medically-cleared, interscholastic athletes were classified into three groups based on self-report of a previous LE (ankle, lower leg, knee, hip) injury: no injury history (NIH) (n=85, males=67.1%, age= 19.4±1.4 yrs, height=176.1±11.9 cm, weight=71.2±12.2 kg); mild injury history (MIH) (n=72, males=52.1%, age=19.2±1.3 yrs, height=175.8±11.4 cm, weight=71.0±13.6 kg); severe injury history (SIH) (n=119, males =47.4%, age=19.4±1.6 yrs, height =174.3±10.9 cm, weight= 71.1±12.7 kg). MIH and SIH were defined as history of an injury that resulted in >1 but <10 days, and ≥10 days of missed athletic participation, respectively. **Interventions:** The independent variable was injury history group. Participants completed the Short Form 12 (SF-12), a valid and reliable PROM, during a single testing session. **Main Outcome Measures:** Dependent variables included the 8 SF-12 subscale scores: physical function (PF), role physical (RP), bodily pain (BP), general health (GH), vitality (VT), social functioning (SF), role emotional (RE), and mental health (MH). Higher scores suggest better HRQOL. To account for negatively skewed score distributions, generalized linear models with inverse Gaussian distributions were used following reflection transformation of dependent variables for group comparisons. Group differences were evaluated with pairwise comparisons (Bonferroni) (alpha=p<.05). Means and standard deviations are reported for all dependent variables. **Results:** Significant differences were found between groups for BP (NIH= 90.6±23.3; MIH=88.5±19.5; SIH= 80.9±27.8) and MH (NIH= 79.7±17.1; MIH=79.3±15.1; SIH= 73.7±20.1), with the SIH group reporting lower scores than the MIH (p<.028) and the NIH (p<.022) groups on BP and MH, respectively. The NIH group reported significantly higher scores on PF (98.8±6.5; p=.028) and RP (94.3± 14.9; p=.022) than the SIH group (PF=96.6±9.7; RP=88.7±18.0), but the MIH group did not significantly (p>.05) differ from the NIH and SIH groups (PF=96.5±12.0; RP=92.7± 11.4). No significant differences (p>.05) were noted for the remaining subscales: GH (NIH=84.5±19.0; MIH=84.9±15.5; SIH=84.4±13.7), VT (NIH=70.0±21.6; MIH=69.8±17.7; SIH=68.1±20.2), SF (NIH=90.9±16.2; MIH=87.2±17.7; SIH=86.6±23.6), RE (NIH=92.8±14.6; MIH=90.3 ±13.7; SIH=88.7±18.6). **Conclusions:** Our results indicate that LE injury history may influence HRQOL, especially in pain and mental health domains. Previous LE injuries may produce long-term impact on health status that extends beyond physical injury recovery and return-to-play. While those with severe injury histories reported lower physical function than those without injury histories, both scores were high and differences may lack clinical meaningfulness. Future studies should investigate how injury history impacts the HRQOL of newly suffered injuries.

Relationship Between Lower Extremity Functional Outcomes in Preoperative Knee Patients

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Context: There is little research in the literature describing performance based functional tests for preoperative knee patients that can be categorized as low to moderate difficulty. **Objective:** Our purpose was to determine the feasibility of incorporating performance based measures preoperatively, and to establish the relationship between these measures for the development of preoperative functional assessment recommendations. **Design:** Observational study. **Setting:** Musculoskeletal Laboratory. **Patients:** Fifteen patient volunteers (5 females, 10 males 30±10 years, 180±10 cm, and 86±18kg) who reported seeking medical care for a knee injury requiring surgery. Patients with a history of surgery or recent injury to the contralateral limb were excluded. **Interventions:** Participants performed the Star Excursion Balance Test(SEBT), Four Square Step Test (FSST), and Step-down test. Unilateral Stance with eyes open(USEO) and eyes closed(USEC), Step Up/Over, and Forward Lunge were performed on NeuroCom Long Forceplate. The uninvolved limb was tested first for all unilateral functional assessments. A 30s rest was provided between each trial, and a 60s rest was provided between tests. The order of assessment was counterbalanced between forceplate and non-forceplate measures. **Main Outcome Measures:** Feasibility was determined based on the percentage of participants that could complete the assessment. Pearson Correlation Coefficients were used to evaluate the relationship between all tests on the involved limb. **Results:** The FSST, SEBT, Step Up/ Over, and Forward Lunge had 100% feasibility. The USEO had 93%

feasibility, USEC and the Step-down had 80% feasibility. The following correlations for SEBT reach measures were observed: SEBT anterior was correlated to posterior-lateral (r=.69, p=.005) and posterior-medial (r=.52, p=.045); SEBT posterior-lateral and posterior-medial (r=.77, p=.005) were moderately correlated. The SEBT anterior reach distance was correlated to several of the functional tests, including Forward Lunge distance (r=.62, p=.013), FSST time (r=-.55, p=.033), and Step-down repetitions (r=.78, p=.001). Forward Lunge distance also correlated with the SEBT posterior-lateral reach (r=.61, p=.015), SEBT posterior-medial reach (r=0.52, p=0.049) and Step-down repetitions (r=.71, p=.003). Step-down repetitions also correlated with SEBT posterior-lateral reach (r=.64, p=.010) and SEBT posterior medial reach (r=0.52, p=0.44). There were no significant correlations between USEO or USEC and any other assessment. **Conclusions:** All directions of the SEBT, Forward Lunge Distance, and Step-down test repetitions were correlated with one another suggesting redundancy in these tests. However, the lower preoperative feasibility of the Step-down test may be evidence of a more challenging task toward which patients can be progressed. The SEBT anterior and FSST were related and all patients were capable of completing these tests prior to surgery thus providing a measure that can be assessed post-surgically to document rehabilitative progress. We propose that the FSST, SEBT anterior, and the Step-down test can be implemented with progressing difficulty throughout rehabilitation as useful assessment tools in a variety of knee patients.

Effectiveness of an Evidence-Based Practice Educational Intervention for Athletic Trainers: A Randomized Controlled Trial

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Context: As evidence-based practice (EBP) becomes a necessity in athletic training, the effectiveness of EBP educational interventions to enhance knowledge must be investigated. Online modules are available to the National Athletic Trainers' Association membership and are a mechanism to educate athletic trainers (AT) on the various concepts of EBP. **Objective:** To assess the effect of an EBP educational intervention on enhancing ATs' knowledge of EBP concepts. **Design:** Randomized controlled trial. **Setting:** Online educational modules and knowledge assessment. **Patients or Other Participants:** 164 of 473 ATs (34.67% response rate) comprising professional AT students, graduate students, clinical instructors/ preceptors, educators, and clinicians were randomized into a control group (40 males, 42 females, age= 34.51± 10.60) or experimental group (33 males, 49 females, age= 34.26 ±9.89). **Interventions**: Ten online modules were developed and consisted of information pertaining to important concepts (eg., literature searching, levels of evidence, disablement models) involved in the EBP process. ATs were solicited via email to participate in this investigation. Both groups completed the *Evidence-Based Practice Knowledge Assessment* prior to and following the intervention phase. During the intervention phase, the experimental group had access to the online modules for a 4-week period. The assessment consisted of 60 multiple-choice questions pertaining to information included within the ten modules. Test-retest reliability was calculated using scores attained from the control group and was determined to be strong (r=0.75, P<0.001). **Main Outcome Measures:** Independent variables consisted of group (control, experimental) and time (pre-assessment, post-assessment). Dependent variables were the scores calculated from participant responses. Knowledge scores were tabulated by awarding 1 point for the correct answer with a maximum achievable score of 60. Between and within group differences were calculated (SPSS 16.0) using a 2x2 repeated measure ANOVA (P≤0.05). In the presence of an interaction or main effect, post-hoc t-tests and Hedge's g effect size (g) with 95% confidence intervals (CI) were calculated. **Results:** A significant group x time interaction (P<0.001) was reported. No differences were identified between groups (M_{CPre}= 30.12±5.73, M_{EPre}= 30.65± 5.93) during the pre-assessment (P= 0.839;g=0.09,CI= -0.22-0.40); however, the experimental group (M_{EPost} =36.35±8.58) obtained signifi-cantly higher scores (P=0.013; g=0.71, CI=0.39-1.02) on the post-assessment compared to the control group (M_{CPost}=30.99±6.33). No differences were identified between time instances within the control group (P=0.080;g= -0.14,CI= -0.45-0.16); however the experimental group obtained significantly higher scores on the post-assessment than the pre-assessment (P<0.001; g=0.77, CI=0.45-1.09). A significant time main effect (P<0.001) and group main effect (P=0.002) were also reported. **Conclusions:** An educational intervention consisting of ten online modules is an effective mechanism to increase ATs knowledge of foundational EBP concepts. However, ATs may not be integrating EBP into daily clinical practice, which may explain why EBP knowledge is lacking even after the implementation of an educational intervention. Future research should determine whether increased knowledge of EBP impacts ATs' daily clinical decision-making.

Quadriceps Performance Profiles and Associations to Subjective Outcome Measures in Patients 12-36 Months Post-Ipsilateral Hamstring Tendons Anterior Cruciate Ligament Reconstruction

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Context: Primary harvest of the ipsilateral hamstring tendons autograft for anterior cruciate ligament (ACL) reconstruction has become prevalent among orthopaedic surgeons. We previously reported knee flexor deficits in patients following this operative technique. However, limited evidence exists in related patients for ensuing quadriceps performance, which is a predictor to knee health-related quality of life (HRQL) post-ACL recon-struction. **Objective:** Our primary aim was to profile knee extensor responses to ipsilateral semitendinosus and gracilis (STG) autograft ACL reconstruction in physically active patients that demonstrated hamstrings performance insufficiencies 12-36 months following surgery. Based on prior research, we hypothesized patients would display quadriceps performance deficits for the involved leg compared to uninvolved and healthy matched

control legs. A secondary aim was to explore associations among subjective outcome measures and objective quadriceps performance. **Design:** Retrospective cohort, Level 2b evidence. **Setting:** A controlled research laboratory. **Patients or Other Participants:** Fifteen (1 man, 14 women) patients (age = 21.2 ± 2.6 years, height = 1.7 ± 0.1 m, mass = 68.7 ± 12.6 kg, Tegner = 6.9 ± 1.6) 27.5 ± 10.9 months postsurgery were matched to 15 (1 man, 14 women) healthy matched control participants (age = 21 ± 1.1 years, height = 1.6 ± 0.1 m, mass = 67.4 ± 10.3 kg, Tegner = 6.3 ± 1.3). **Interventions:** The independent variable was the operative technique. Isokinetic strength and endurance were measured at angular velocities of 60 º/s and 240 º/s respectively using reliable methods. Subjective measures included the reliable Knee Outcome Survey (KOS) and Knee Injury and Osteoarthritis Outcome Score (KOOS). Respective one-tail dependent and independent t-tests were calculated to determine within patient and between participant differences. Correlation coefficients were computed among the KOS and KOOS to quadriceps performance. $P < 0.05$ denoted statistical significance. **Main Outcome Measures:** Dependent variables included: normalized peak moment and total work; time to peak moment; angle of peak moment; KOS and KOOS subscale scores. **Results:** Data were normally distributed. Patients demonstrated a significant difference for angle of peak moment with the involved (73.0 ± 11.9 °) compared to uninvolved (77.4 ± 12.1 °) leg ($P = 0.022$). Patients also displayed a significant correlation among the KOOS Sports subscale score and extensor strength ($r = -0.533$, $P = 0.041$) for the involved leg. All other measures were insignificant ($P > 0.05$). **Conclusions:** The shallower angle of extensor peak moment may be attributed to hamstrings antagonistic deficits to quadriceps induced knee extension associated with donor-site morbidity. An inverse relationship among the KOOS Sports subscale score and extensor peak moment indicates patients perceived better subjective athletic outcomes with lesser quadriceps strength in the presence of hamstrings weakness. Our findings advocate continued investigation for determining factors associated with knee HRQL in ACL reconstructed patients. *Funded by the Pennsylvania Athletic Trainers' Society, Inc. Supported Research Grant*

Effects of Baseball Participation and Pitching on Humeral Retrotorsion in High School Baseball Players

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Context: Torsional stress placed on baseball players' dominant limb during throwing/pitching has been theorized to negate or reverse the de-rotation of the humerus that naturally occurs during skeletal maturity. As a result, baseball players' dominant limbs demonstrate increased humeral retrotorsion. However, no study has investigated the effects of baseball participation and pitching on changes in humeral retrotorsion using a longitudinal study design. **Objective:** To investigate the effects of baseball participation and pitching on changes in humeral retrotorsion over a 1-year period in high school baseball players. **Design:** Longitudinal study design. **Setting:** High school baseball teams. **Patients or Other Participants:** A total of 339 baseball players were tested in spring of 2010. Data from 100 returners with complete data (age=16.1±0.8years, height= 180.4 ±6.4cm, mass= 74.9± 10.9kg) were analyzed. **Interventions:** Humeral retrotorsion was measured in spring of 2010 and 2011 using a digital inclinometer and diagnostic ultrasound. Participants also completed a questionnaire to report their baseball participation and pitching during the 2010 spring, summer, and fall seasons. **Main Outcome Measures:** Change in humeral retrotorsion between spring of 2010 and 2011 was calculated. A total numbers of seasons that participants 1) played baseball and 2) pitched on organized teams in 2010 were calculated from the questionnaire responses. Change in humeral retrotorsion was compared between 1) participants who played baseball in 1, 2, and 3 seasons, and 2) participants who pitched in 0, 1, 2, and 3 seasons using 2 separate one-way ANOVA. Additionally, using a minimal detectable difference of 6.4° (calculated from 2.3° standard error of measure-ment) as a threshold criterion, association between proportion of participants with increased (change> 6.4°) and decreased (change<-6.4°) humeral retrotorsion and baseball participation/pitching were evaluated using Fisher's exact tests. **Results:** There were no significant changes in humeral retrotorsion between participants who played baseball in 1, 2, and 3 seasons ($F_{(2,97)}=1.0$, p=.36), or between participants who pitched in 0, 1, 2, and 3 seasons ($F_{(2,97)}=0.02$, p=.89). Humeral retrotorsion decreased in 18 (16.7%) and increased in 17 (15.7%) participants. However, these changes were not associated with numbers of seasons participants played baseball (p=.34) or pitched (p=.91) in 2010. **Conclusions:** Understanding the effects of participation and pitching on humeral retrotorsion is important since skeletal adaptation or lack-thereof has been linked to upper extremity pain/injury in overhead athletes. Our results indicate that humeral retrotorsion may increase or decrease over a 1-year period in some high school baseball players, yet these changes may not be related to baseball participation or pitching. This may be attributed to the fact that participants were approaching the end of skeletal maturity and that majority of skeletal adaptation due to baseball participation/pitching occurs at a younger age. A longitudinal study examining the effects of participation/ pitching on humeral retrotorsion in younger participants is warranted.

Critical Review of Self-Reported FAI Measures: AII, CAIT, IdFAI

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Context: Functional Ankle Instability (FAI) lacks a gold standard measure or universally accepted inclusion criteria. As a result a wide variety of self-reported ankle instability measures have been developed for use in FAI research. Recent research has advocated the combined usage of the Ankle Instability Instrument (AII) and Cumberland Ankle Instability Tool (CAIT) to properly identify people with FAI. Additionally, the Identification of Functional Ankle Instability (IdFAI) is a recently introduced questionnaire designed specifically to identify FAI. **Objective:** Determine which ankle instability instrument (AII, CAIT, IdFAI) best classifies subjects based on a minimum accepted criteria for FAI. **Design:** Cross-sectional study **Setting:** University classroom **Participants:** One thousand one hundred and thirty five college aged subjects (573 males, 536 females, 19.56 ± 2.05 years) were recruited from a large Midwestern university population. Individuals with a history of lower limb fracture were excluded. **Interventions:** The independent variables were the score on the AII, CAIT, and IdFAI. Subjects were asked to complete all three questionnaires in one testing session and were instructed to complete each questionnaire for their dominant limb. **Main Outcome Measures:** A discriminant function analysis was conducted to measure the ability of the predictor variables (AII, CAIT, IdFAI) to classify subject by ankle stability status (grouping variable). The group variable was created based on the previously established minimum acceptable criteria for FAI (MC_FAI). This criterion was established as at least one ankle sprain and at least one episode of giving way. In addition, sensitivity and specificity were calculated for all predictors. **Results:** The use of the IdFAI yielded an overall correct classification rate of 85%, while the CAIT and AII resulted in an overall correct classification of 68% and 82%, respectively. Subjects in the MC_FAI group (unstable group) were correctly classified 78% by the IDFAI (16.36±5.54), 49% by the CAIT (21.81±5.82), and 78% by the AII (mean score 4.38±1.85). Subjects were correctly classified in the no MC_FAI group (stable group) 90% of the time by the IdFAI (5.15±4.71), 84% by CAIT (26.50±8.22), and 81% by the AII (mean score 1.38±1.57). Sensitivity was similar for AII (0.79, CI: 0.75-0.82) and the CAIT (0.73, CI: 0.68-0.78) but slightly higher for the IdFAI (0.87, CI: 0.84-0.90). While specificity for the AII (0.84, CI: 0.81-0.87) and IdFAI (0.83, CI: 0.79-0.85) were similar, and the CAIT (0.66, CI: 0.63-0.70) was notably lower. **Conclusions:** This analysis illustrates that IdFAI is a good overall option available for classification of ankle stability status by self-reported questionnaire. The IdFAI is new questionnaire but these finding identify that it: 1.) demonstrated a higher overall correct classification percentage and 2.) has better overall sensitivity and specificity. Funded by the NATA Foundation General Grant Program.

Gender Plays a Role in Deep Tissue Cooling Independent of Skinfold Thickness

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Context: Scientists have observed thicker skinfolds delay intramuscular tissue cooling. These studies have not examined the influence of gender on tissue cooling though females commonly have thicker skinfolds. **Objective**: To determine what role gender plays in tissue cooling, when controlling for skinfold thickness. **Design**: Cross-sectional study. **Setting**: Laboratory. **Patients or Other Participants**: Thirty recreationally active individuals (male: n=15, age= 26±4y, ht=180.7±11.9cm, mass= 80.7±12.2kg; female: n=15, age= 21 ±2y, ht=166.6±8.4cm, mass= 64.5 ±7.9kg) participated. **Interventions**: Three anterior thigh (½ the distance between ASIS and base of the patella) skinfold measurements were averaged for each participant. Subjects lay supine while a multi-probe was inserted into the thigh at the skinfold measurement site. The multi-probe recorded intramuscular temperature at 4.0cm, 3.25cm, and 2.5cm below the skin surface. Temperatures were recorded at each depth every 10 min during a 10 min baseline, 60 min ice bag (1kg) application, and 30 min re-warming. Ice bags were shaken every 5 minutes. Data were analyzed using three (one for each thermocouple depth) 2 (gender) x 10 (time) repeated measures ANOVAs with Greenhouse-Geisser corrections. These procedures were repeated with average skinfold thickness as a covariate. Multiple independent sample t-tests were performed to determine where differences occurred and effect sizes (ES) with effect size confidence intervals (in brackets) were calculated. Significance was accepted when $P \leq 0.05$. **Main Outcome Measures**: Temperature (°C). **Results**: Male skinfolds (13.0±5.3mm) differed from female skinfolds (25.4±6.1mm; $P<0.001$, ES=2.14 [1.24 to 3.03]). Subjects did not differ at the beginning of ice application (4cm: males = 36.8±0.4°C, females = 36.9±0.5°C, $P=0.64$; 3.25cm: males = 36.4±0.4°C, females = 36.6±0.7°C, $P=.31$; 2.5cm: males = 36.2±0.5°C, females = 36.6± 1.0°C, $P=0.21$). At 4cm, a gender* time interaction was observed ($P<0.001$). Males differed from females after 60 min of icing (32.0±0.7°C vs. 33.3±1.2°C; ES=1.23 [0.45 to 2.01]) and throughout rewarming (10 min: 31.2±0.8°C vs. 32.4±1.5°C, ES=1.01 [0.25 to 1.77]; 20 min: 30.8±0.8°C vs. 32.2±1.4°C, ES=1.29 [0.51 to 2.08]; 30 min: 31.1±0.8°C vs. 32.4±1.4°C, ES=1.18 [0.41 to 1.96]). A gender*time interaction was also observed at

3.25cm (P=0.02). Males differed from females after 40 min of icing (31.9±1.0°C vs. 32.4±1.6°C; ES=0.44 [-0.29 to 1.16]), after 60 min of icing (29.6±1.1°C vs. 30.8±1.8°C; ES=0.74 [0.00 to 1.48]), and throughout rewarming (10 min: 28.7±1.1°C vs. 29.9±1.9°C, ES=0.77 [0.03 to 1.51]; 20 min: 28.6±1.1°C vs. 30.1±1.8°C, ES=1.03 [0.27 to 1.79]; 30 min: 29.2±1.1°C vs. 30.6±1.7°C, ES=0.96 [0.20 to 1.71]). At 2.5cm, there was no interaction (P=0.15) or gender (P=0.19) effect, only a time effect (P<0.001). **Conclusions**: At deeper intramuscular depths (i.e., 3.25 and 4cm), and with a 60 min ice application, males cooled faster than females, irrespective of skinfold. Additional research is needed to explain why males cooled faster than females and whether these observations have clinical significance.

Inhibition of TGF-b Following Eccentric Muscle Injury Results in an Initial Improvement but Long Term Deficit in Force Production

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Context: Transforming growth factor-beta (TGF-b) is a cytokine that can cause fibrosis and inflammation following injury in a variety of tissues. Previous studies in our lab have shown that treating skeletal muscles with TGF-b results in a dramatic accumulation of type I collagen, substantial muscle fiber atrophy and a marked decrease in force production. Inhibiting TGF-b might improve the treatment of eccentric muscle injuries. **Objective:** Our objective was to investigate whether the inhibition of TGF-b would enhance the recovery of muscle following eccentric contraction-induced injury. We hypothesized that inhibiting TGF-b after eccentric muscle injury would improve the recovery of force production by limiting the accumulation of fibrotic scar tissue and preventing atrophy of muscle fibers. **Design:** Animal-model study. **Setting:** Controlled laboratory. **Patients or Other Participants:** N/A. **Interventions:** Mice were subjected to a contraction-induced injury protocol of their ankle dorsiflexors and allowed to recover for a period of 3, 7 or 21 days. A monoclonal antibody that inhibits TGF-b (1D11) was given to the experimental group, while the control group received sham immunoglobulin injections (MOPC21). **Main Outcome Measures:** Peak isometric force production was measured and compared to the pre-injury value. EDL muscles were then removed for immunohistochemistry to analyze fiber size and morphology. Differences between groups at each time point were tested using t-tests. **Results:** Compared with mice that received sham IgG, muscles from mice receiving the TGF-b inhibitor showed a greater recovery in force at 3 and 7 days post-injury. However, mice that received sham IgG had a full recovery of force production while mice that received the TGF-b inhibitor had not fully recovered at the 21 day time point. TGF-b inhibition protected muscles from atrophy and had more centrally located nuclei, suggesting enhanced early regeneration of muscle fibers at 3 and 7 days post-injury. For the same time points, compared with mice that received sham IgG, muscles treated with TGF-b inhibitor exhibited less injury-induced atrophy and an attenuation of collagen I signal. Interestingly, at 21 days post-injury, although the fibers appear to be regenerated and the amount of ECM around the muscle fibers was not different, appearance of the ECM from the TGF-b inhibitor treated muscles appeared mottled and ruffled compared to controls. **Conclusions:** The results from the current study indicate that inhibiting TGF-b during the initial stages of muscle injury results in a short-term improvement in muscle function, but a long-term deficit in force production. While further studies are necessary, the mottled appearance of the ECM at 21 days suggests that matrix proteins might play an important role in supporting a full regenerative response. Funded by the NATA Foundation General Grant Program.

The Effect of Kinesio Tape on Force Sense in People with Functional Ankle Instability

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Context: Previous research testing the effect of Kinesio Tape (KT) on proprioception has shown conflicting results. Force sense is a method of evaluating proprioception of the ankle. To date, this measure has not been used in the KT research. **Objective**: To evaluate the effect of KT on force sense errors in subjects with functional ankle instability (FAI). **Design**: Controlled laboratory study. **Setting**: Research Laboratory **Patients or Other Participants**: Forty subjects volunteered to participate in this study. Twenty subjects (6 male, 14 female, 22.0± 2.6yrs, 169.8±9.1cm, 69.0± 14.8kg) who had healthy ankles were included in the control group. Twenty subjects (8 male, 12 female, 21.0± 1.4yrs, 172.0±9.3cm, 74.4± 12.4kg) who had FAI were included in the injured group. All FAI subjects had a history of a lateral ankle sprain and frequent (weekly) episodes of ankle giving way. The FAI subjects were further divided into 10 subjects with severe FAI (FAI-S) and 10 subjects with mild FAI (FAI-M) based on the baseline proprioceptive deficits. **Interventions**: KT was applied to the FAI ankle of the FAI-S and FAI-M subjects using the standard lateral ankle sprain tape application identified in the Kinesio® Perfect Taping Manual. Subjects in the control group received no tape application, but "rested" during the tape application time. Ankle proprioception was measured using force sense testing at 30% of eversion MVIC. Using a load cell (Sensotec, Columbus, OH), subjects were asked to produce the target force using a visual cue and hold the force for 5 seconds, relax, and then reproduce the force without a visual cue. The difference between the target and reproduction force was used to calculate an error score. Force sense testing was conducted on all subjects on four occasions: baseline, immediately after tape application (or rest), 72 hours after tape application (or rest), immediately following tape removal (or rest). A two-factor Repeated Measures Analysis of Variance (RMANOVA) with one between subjects factor (group at three levels) and one within subjects factor (time at four levels) was calculated. A Tukey post-hoc analysis was performed on any significant findings. Alpha level was set at $p<.05$. **Main Outcome Measures**: Force sense errors in Newtons(N). **Results:** Results of the RMANOVA revealed a significant time by group interaction ($F_{6,111}=2.4$, $p=.03$). Specifically, the FAI-S group demonstrated decreased force sense errors after wearing the KT for 72 hours (2.2±1.4N) compared to baseline (3.0±0.9N). The decreased errors were maintained in the FAI-S group even after the KT was removed (1.9±0.9N). Conversely, neither the control or FAI-M groups showed any changes in force sense errors at any of the test times ($p>.05$). **Conclusion**: We found that wearing KT decreased force sense errors in subjects with severe FAI. The decreased errors were maintained even after the tape was removed.

Kinesiotape Does Not Increase Glenohumeral Internal and External Range of Motion of the Shoulder

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Context: Kinesio tape (KT) is theorized to restore correct muscle function, improve blood and lymphatic flow, decrease pain, and correct malaligned joints. Literature indicates that KTimproves proprioception, musculature strength, and perceptions of pain, but range of motion (ROM), specifically of the shoulder has yet to be assessed. **Objective**: To determine the effects of KT on shoulderROM arc pre and post KT treatment. **Design**: We used an experimental, pretest-posttest randomized-groups design to evaluate the effect of KT. **Setting**: Data collectionoccurredin auniversity research laboratory. **Participants**: Healthy volunteers(n=45; males=17, females=28) between the ages of 18-40 completed the investigation. **Interventions**: Independent variables consisted of treatment at two levels: KT and no KT. Participants were randomly assigned to two groups (control=22, KT=23). We measured baseline glenohumeral internal rotation (IR) and external rotation (ER) in the control group on day one and re-measured on day four. We measured KT group baseline IR and ER on day one prior to and following the application of KT and then again on day four pre and post-removal of the KT.IR and ERwas measured three times for each measurement pre/post with an inclinometer while supine. Interrater reliability or ROM measurement with the inclinometer was strong (IR r=0.91, ER r=0.96).We applied the tape in two strips, one I-shaped to stabilize the scapula and one Y-shaped around the infraspinatus and suppraspinatus. **Main Outcome Measures**: We calculated frequencies

and means to assess demographic data. We analyzed the data using two separate ANOVA to identify the differences between gender and the control/KT group ROM arc and between pre and post treatment control/KT treatment groups. **Results**: We observed no differences in shoulder ROM arc between the control and KT treatment groups. Significant differences between the control and KT treatment groups did not exist for shoulder ROM arc pre and post intervention (P<.05). Significant differences between genders in the control and KT group were identified on day 4 for females in the KT group pre tape removal ($F_{1,44}$=7.47, p=0.008). Shoulder ROM arc measurements indicate that females have a greater shoulder ROM arc (125.00±SD) compared to men (115.00±SD) for day 4 pre KT tape removal. **Conclusions**: Resultssuggest that KT has no effect on shoulder ROM arc. Interestingly females displayed a significant increase in ROM arc withKT after the 4 days of treatment, returning to a non-effect upon tape removal. KT may have some beneficial properties while on the patient; however differences in male and female shoulder ROM arc pre tape removal should be assessed for the effect of tape placement or physical activity. Although KT use for ROM may not be effective, KT may have an effect on blood flow and pain and should be evaluated.

Assessing the Effectiveness of the Stirrup, Horseshoe, Heel-lock, and Figure-8 Components of the Closed Basketweave Ankle Taping Method in Various Combinations

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Context: The most widely accepted adhesive taping method used to treat and prevent lateral ankle sprains is the closed basket-weave ankle taping. Despite being the most common technique, little research exists regarding the effectiveness of the components of this method. **Objective:** 1.)To establish which of the 4 individual components of the closed basket-weave ankle taping (HS, HL, SU, F8) are most effective in restricting ankle motion. 2.)To establish which combination of components is most effective at restricting ankle motion. **Design:** Cross-sectional study. **Setting:** Research laboratory. **Participants:** Twenty healthy participants (8 males/ 12 females, 19.8±1.7 years, 172.5± 10.3cm, 70.0±12.7kg) with no history of lower extremity surgery and no lower extremity injury within six months of testing volunteered to participate. **Interventions:** Nine taping conditions were applied to the dominant leg of each subject. Conditions included: no tape(NT), Horseshoes (HS), Stirrups(SU), Heel-locks(HL), Figure-8's(F8), HL/F8, SU/HS, SU/HS/F8, and the complete closed basketweave(CBW). For each taping conditions two heel and lace pads(Mueller) were placed on the ankle followed by adhesive tape spray(Super Tape Adherent). Then a single layer of foam pre-wrap (Mueller) was applied in a circular pattern followed by two anchor strips using 1½ inch cloth athletic tape(Zonas), one at the base of the gastrocnemius and another at the base of the metatarsals. Then each tape condition was applied. Ankle range of motion was measured using an ankle electrogoniometer after each tape condition. **Main Outcome Measure:** Ankle range of motion(°) was measured in four motions: eversion, inversion, dorsiflexion, and plantar-flexion. Four repeated measures ANOVA, one for each direction, were conducted on the taping conditions. A Tukey post hoc test was conducted on any significant findings. A priori alpha level was set at p<.05. **Results:** For inversion and plantarflexion, a significant difference was displayed among the 9 taping conditions. ($F_{8,152}$=28.40, p=.01 and $F_{8,152}$=29.78, p=.01, respectively). For both of these directions a difference was found between NT (inversion: 32.1° ±5.8, plantarflexion: 28.4°±5.4) and all other tape conditions except HS (inversion: 28.7°±6.2, plantarflexion: 26.9°±4.7). Eversion results also showed a significant difference among the 9 taping conditions ($F_{8,152}$=6.83, p=.01). However, differences were only identified between NT(15.81° ±3.81) and SU/F8/HL(11.33°± 3.21) and CBW(11.45°±3.44). Dorsiflexion results yielded a significant difference among the 9 taping conditions. ($F_{8,152}$ = 16.03, p =.01) The post hoc test identified a significant difference between NT and all 9 tape conditions. **Conclusion:** Generally, the components and combination of components of the closed basketweave ankle technique effectively restrict range of motion at the ankle. However, these findings suggest that the horseshoe component could be removed from the closed basketweave ankle taping method due to its inability to effectively restrict inversion or plantarflexion range of motion.

Five-Toed Socks Do Not Alter Reflex Excitability in Ankle Stabilizing Muscles

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Context: Postural control deficits contribute to disability in various patient populations as well as impacting optimal physical performance in healthy athletes. Five-toed socks with plantar tactile (FTST) enhancement have been hypothesized to improve postural control by increasing afferent signals from plantar cutaneous mechanoreceptors. Currently, it remains unknown if these socks alter reflex excitability in ankle stabilizing musculature, which could be a potential mechanism explaining gross neuromuscular improvements, such as postural control, from wearing these socks. **Objective:** To determine if FTST and five-toed socks without tactile enhancement (FTS) alter reflex excitability in the tibialis anterior (TA), fibularis longus (FL), and soleus muscles during double limb stance compared to wearing regular socks (RS) or no socks (NS) in healthy participants. **Design:** Crossover. **Setting:** Research Laboratory.

Patients or Other Participants: Fourteen participants (5 males, 9 females; age 22.9±3.4 years; height 170.1±7.3 cm, weight 67.6±9.5 kg; BMI 23.4±3.5) completed all 4 sessions. **Interventions:** Pre and post-test measurements were conducted on 4 separate days, within a 7 day window, in which 1 of the 4 sock conditions was applied (FTST, FTS, RS, NS). The order of sock condition was randomized and measurements were performed at the same time each day. For reflex testing, a 1ms square wave stimulus of various intensity was applied to the sciatic nerve complex in the popliteal fossa in a manner that could elicited maximal reflex measurements in the TA, FL and soleus musculature of the dominant leg for each individual. Surface electromyography was used to record these measurements as participants stood in double limb support. **Main Outcome Measures:** Maximal Hoffmann reflexes normalized to a maximal muscle responses (H:M) were collected. Percent change scores were calculated from pre and posttest H:M measurements in each session. This allowed for the assessment of the change in H:M caused by the sock conditions above the normal variation in reflex excitability evaluated in the NS condition. Separate, 1x4 ANOVAs were used to evaluate differences in H:M percent change between sock conditions in each muscle. Alpha levels were set a priori at P≤0.05. **Results:** There were no significant differences in H:M percent change scores between sock conditions for tibialis anterior (FTST=5.62±20.23%, FTS= 0.33± 24.61%, RS=6.92±26.32%, NS= 8.59±33.66%; $F_{3, 55}$=0.252, P= 0.86%), fibularis longus (FTST= 7.07±26.73%, FTS= 14.56±28.51%, RS=1.01±27.82%, NS=0.4±29.17; $F_{3, 55}$=.77, P=.56), or soleus H:M ratio (FTST=9.77±17%, FTS= 10.9± 37.06%, RS=0.86±17.68%, NS= 13.09±45.71%; $F_{3, 55}$=0.40, P=0.76). **Conclusion:** Spinal reflexes of ankle stabilizing muscles were not altered during double limb support in healthy

Effects of Five-Toed Socks on Dynamic Postural Control and Subjective Characteristics during Jump-Landing in Individuals with Chronic Ankle Instability

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Context: Previous studies have demonstrated that wearing five-toed socks with multiple rubber bits on the foot sole (FTS) improves static and dynamic postural controlin individuals with chronic ankle instability (CAI), possibly through enhanced plantar tactile feedback and foot gripping. However, it is unclear if FTS have similar effects on dynamic postural control during activities such as a jump-landing task. Additionally, self-reported subjective characteristicsconcerning comfort, stability, and confidence in preventingan ankle injury when wearing FRB have not been considered. **Objective:** To assess the effect of FTS on dynamic postural controland subjectivefeelings during a jump-landing task among individuals withCAI. **Design:** Crossover design. **Setting:** Research laboratory. **Patients or Other Participants:** Twenty-four participants with CAI (8M, 16F: 20.6±2.1yrs, 167.1 ±10.1 cm,65.7±11.6kg) volunteered. **Interventions:** Participants completed a one-time testing session to quantify dynamic postural control and subjective feelingsofcomfort, stability, and confidence in protecting the ankle from a potential injurious situationunder two sock conditions: FTS and regular socks (RS). The order of the sock condition was randomized and athletic shoes were worn for all testing. The jump-landing task consisted of a single-leg landing from 50% of the participant's maximum jump height. Participants jumped off both feet, reached up and touched the indicated marker, and landed on a forceplate onthetesting limb. Three trials were performed with each sock condition. Ground reaction forces were used to calculate Resultant VectorTime to Stabilization (RVTTS, seconds), with longer values indicative of poorer dynamic stability.After the jump-landing procedure was com-pleted in each sock condition, three separate 10-point visual analogue scale measures were completed asking about subjective characteristics concerning: 1) perceived comfort (PC), 2) per-ceived stability (PS), and 3) perceivedconfidence (PC)in protect-ing the ankle from a potential injurious situation. **Main Outcome Measure(s):** The dependent variables werethe dynamic postural control measure (RVTTS) and the subjective characteristics(PC, PS and PC). The independent variable was the sock condition (FTS, RS). For each dependent variable (RVTTS, PC, PS, PC), a separate paired t-test was performed for comparison between the sock conditions.Significance was set a priori at P≤0.05. **Results:** PS was significantly higher in FTS (4.83± 1.83) than RS (3.54±1.77; $t_{1,22}$=3.89, P=0.01), as was PC (FTS=4.48±1.80, RS=2.96±1.99, $t_{1,22}$=4.22, P=0.01). No significant difference was observed for PC (FTS=5.63±1.13, RS=5.67±1.71, $t_{1,22}$=-0.13, P=0.90) or RVTTS (FTS=2.17±0.41, RS= 2.18±0.07, $t_{1,22}$=-1.04, P=0.31). **Conclusions:** These results indicate thatwearing FTS is associated with improved perceivedstabilityand confidence in protecting the ankle from a potential injurious situation during jump-landing. However, dynamic postural control, as measured by RVTTS was not influenced with the FTS. The subjectively assessed positive benefits with FTS may provide some direction for utilizing these as an intervention for CAI.

Kinesio®tape Application Does Not Improve Shoulder Proprioception or Strength in Healthy, Physically Active Participants

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Context: Kinesio®tape (KT) is used clinically to treat a wide range of conditions, from musculoskeletal injuries to myofascial restrictions, with reported effects of pain reduction, inhibition or facilitation of motor activity, enhancement of proprioceptive feedback, and promotion of postural alignment and joint stability. Despite the growing use of KT, there is little evidence-based research to support or refute these claims. **Objective:** To determine the effect of KT on shoulder proprioception and strength in healthy individuals and to determine if the effects are time-dependent. **Design:** Quasi-experimental repeated measures study. **Setting:** Research laboratory. **Participants:** Data were collected on 10 healthy, physically active participants (age=25.78±3.78 years, height=1.69±0.09 m, mass=67.18 ±14.25 kg). All subjects were free of current medical or musculoskeletal shoulder pathology and had no previous history of major shoulder pathology. **Interventions:** Shoulder proprioception was assessed using an isokinetic dynamometer operating in the passive mode (0.25°/s) for threshold to detect passive motion and direction (TTDPMD) into shoulder internal/external rotation (IR/ER, 3 repetitions each). Isokinetic shoulder IR/ER strength was assessed using an isokinetic dynamometer (60°/s, 5 repetitions each). All tests were performed on the dominant side (arm with which would use to maximally throw a ball). Participants were tested at four time points: immediately before KT application (T1), immediately post-application (T2), 24-48hrs post-application (T3) (KT removed after this test session), and 24-48hrs post-removal (T4). KT was applied by a Certified Kinesio®tape Practitioner. Variables were analyzed using Friedman's analysis of variance. Statistical significance was set at $p<0.05$ *a priori*. **Main Outcome Measures:** For TTDPMD, mean absolute error in degrees was calculated for shoulder IR/ER. Peak torque was averaged normalized to body weight (%BW) for shoulder IR/ER. **Results:** There were no significant differences in TTDPMD into IR (T1=3.92°±4.89°, T2=4.36° ±6.02°, T3=3.03°±2.16°, T4=3.30° ±5.00°, p=0.198) or ER (T1=3.67°± 5.12°, T2=3.87°±4.32°, T3=2.66°± 3.43°, T4= 2.98°± 3.33°,p =0.494) or for shoulder IR (T1= 34.0 ±15.4%, T2=32.0±12.7%, T3= 34.3± 16.5%, T4=34.5±14.3%, p=0.218) or ER strength (T1=29.0 ±8.5%, T2=28.9 ±10.6%, T3=29.0 ±10.6%, T4=29.4 ±10.6%, p=0.476) across all time points. **Conclusions:** The application of KT to the shoulder in healthy, physically active individuals does not appear to aid or impair shoulder proprioceptive ability or strength. Future research should explore if similar results can be replicated in subjects with shoulder pathology as well as in other joints and conditions in order to support the clinical use of KT. Supported by Freddie H. Fu, MD Graduate Research Award & University of Pittsburgh, School of Health & Rehabilitation Sciences Research Development Fund

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Lower-Leg Kinesio® Tape Application Reduces Rate of Loading in Healthy Subjects

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Context: Kinesio® taping is a method that has become widely used in sports medicine over recent years for various pathologies. Some proposed uses include improving proprioception and providing mechanical support; however, little evidence exists as to the efficacy of this taping. Previous research refutes claims of proprioceptive benefits; however, it is unclear how Kinesio® tape, as applied to the lower leg, may affect forces and pressures of the foot. **Objective:** To examine the effects of lower leg Kinesio® taping on plantar forces and pressures in a group of healthy subjects. **Design:** Pre-test post-test. **Setting:** Biomechanics Laboratory. **Patients or Other Participants:** Twenty physically active subjects (10 male, 10 female) with no history of exercise-related leg pain volunteered for this study (20.2±1.5yrs, 173.2±11.7cm 76.9± 14.4kg). **Interventions:** Subjects were asked to walk barefoot across a Tekscan, Inc. (Boston, MA) pressure mat system under one of 3 conditions: prior to tape application (PRE), immediately following application of Kinesio® tape to the lower leg (KT-I), and following 24 hours of Kinesio® tape use (KT-24). Tape was applied directly to the skin from the superior third of the medial tibia to the arch of the foot at 75% tension. Five trials were collected for each condition to ensure a reliable recording. **Main Outcome Measures:** Each trial was partitioned so that the foot was divided into six areas: medial rearfoot, lateral rearfoot, medial midfoot, lateral midfoot, medial forefoot, and lateral forefoot. The dependent variables included peak force (N) and pressure (kPa), mean force (N) and pressure (kPa), and time-to-peak force (% stance) and pressure (% stance). A repeated-measures analysis of variance was used to determine if dependent variables differed between tape conditions and foot areas ($\alpha=0.05$). **Results:** There was a significant main effect of foot area for all variables ($F>169.0$, $p<0.001$). Additionally, a significant main effect of condition was observed for time-to-peak force ($F=4.60$, $p=0.011$), and time-to-peak pressure ($F=3.58$, $p=0.029$). Post-hoc tests revealed that time-to-peak force did

not change from PRE (39.5±23.5%) to K-I (41.3±23.6%, p=0.16), but had a significant decrease at KT-24 (42.4±23.6%, p=0.008). A similar effect was observed for time-to-peak pressure at PRE (40.8±25.0%), KT-I (42.9±25.7%), and KT-24 (43.8± 25.7%, p=0.026). **Conclusions:** Our results suggest that prolonged use of Kinesio® tape on the lower leg may reduce the rate of loading throughout the foot. While research has supported a mechanical effect of Kinesio® tape on various joints, this study does not appear to support that finding as initial application of the tape did not produce an effect. However, changes in timing of peak force and pressures suggest the tape may have a neuromuscular effect. Future research should assess how muscle activity is altered by tape use, and how this effect may be beneficial in pathological populations.

The Influence of EFX® on Isokinetic Strength

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Context: Muscle strength is an important physiological factor that can affect performance in dynamic environments such as athletic competition and physical recreation. Intuitively reasoned, an increase in muscle strength is associated with an improvement in performance. **Objective**: This research study examined the effects of a commercial sporting goods accessory, EFX® (www.efxusa.com), on muscle strength. **Design**: Double blinded crossover study. **Setting**: Research laboratory. **Patients or Other Participants**: 30 healthy participants (males = 17, females = 13) (age = 21.9 ±3.1 years, mass = 73.2 ±16.0 kg, height = 170.9 ±8.1 cm) with no history of current or recent injury involving their lower extremities. **Interventions**: EFX® is a commercial product that is readily available to the general public as an accessory via sporting goods department stores, sporting events, and the Internet. The products are commonly available in the form of silicone bracelets and necklaces each containing a plastic holographic dot. According to manufacturer information, each dot is "programmed with algorithms and frequencies that interact positively with the energy field at the cellular level". Independent variable was treatment condition: activated dot (EFX), non-activated dot (XFE), and no dot (CO). Participants completed one testing session that consisted of performing isokinetic testing under the three conditions. For each condition, subjects completed one set of five repetitions at the speeds of 60°, 180°, 300°·s^{-1}. An isokinetic dynamometer (Biodex, Shirley, NY) was used to assess concentric knee extension (quadriceps) and flexion (hamstring) muscle strengths. **Main Outcome Measures**: Dependent variables for strength: peak torque (N·m) for quadriceps and hamstring muscles. An ANOVA with repeated measures was used to assess differences between treatment conditions on peak torque. **Results**: No differences between treatment conditions (mean ±SD) were found for peak torque: quadriceps 60°·s^{-1} (EFX 154.2 ±50.2, XFE 149.6 ±46.5, CO 151.3 ±50.1, P = .538, 1-β= .850), 180°·s^{-1} (EFX 109.5 ±34.2, XFE 108.4 ±36.1, CO 108.6 ±33.9, P = .831, 1-β= .922), 300°·s^{-1} (EFX 79.1 ±26.9, XFE 79.3 ±26.6, CO 79.4 ±24.8, P = .976, 1-β= .946); hamstring(s) 60°·s^{-1} (EFX 81.5 ±24.7, XFE 79.7 ±24.1, CO 80.6 ±25.1, P = .599, 1-β= .869), 180°·s^{-1} (EFX 55.6 ±18.9, XFE 54.5 ±18.8, CO 54.8 ±18.4, P = .540, 1-β= .851), 300°·s^{-1} (EFX 39.1 ±15.4, XFE 39.2 ±14.8, CO 40.0 ±15.2, P = .623, 1-β= .876). **Conclusions**: Our results indicate isokinetic strength of the quadriceps and hamstring muscles were not improved with the incorporation of the EFX® dot. The effectiveness of EFX® and other similar products are supported primarily through theoretical models provided by manufacturers and testimonials from clients. While the research evidence does not seem to support anecdotal claims, popularity of "wearable" performance technology continues to grow, warranting further investigation.

The Impact of EFX® on ImPACT™

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Context: Performance technology products embedded in silicone bracelets and necklaces are becoming increasingly popular with active individuals in the recreational and competitive athletic communities. Reports from users have indicated benefits in physical performance (e.g., balance, strength) and cognitive functions (e.g., alertness, concentration). **Objective**: The purpose of this research study was to examine the effects of EFX® (www.efxusa.com) on cognition. **Design**: Double blinded crossover study. **Setting**: Research laboratory. **Patients or Other Participants**: 30 healthy participants (males = 10, females = 20) (age = 21.67 ±2.4 years, mass = 67.6 ±13.2 kg, height = 167.7 ±8.5 cm) with no history of current or recent head injury. **Interventions**: EFX® is a commercial product, commonly marketed as silicone bracelets and necklaces, available via sporting goods department stores, sporting events, and the Internet. Each item contains a plastic dot that is reported to be "embedded with wearable holographic technology". Independent variable was treatment condition: activated dot (EFX), non-activated dot (XFE), and no dot (CO). Participants completed one testing session consisting of a computerized program (ImPACT™) under the three conditions. The order of treatment condition was randomized for each subject. Both the subject and test administrator were blinded to the order of the treatment conditions. ImPACT™ (ImPACT Applications, Inc.) is a commercially available computerized program commonly utilized as part of the neurocognitive assessment and management of concussions. Subjects complete six different modules from which composite scores are calculated

for measurements of memory, reaction time, and processing speed. **Main Outcome Measures**: Dependent variables: composite scores for ImPACT™: Verbal Memory (VRM), Visual Memory (VSM), Visual Motor Speed (VMS), Reaction Time (RT), and Impulse Control (IC). An ANOVA with repeated measures was used to assess differences between treatment conditions. **Results**: No differences between treatment conditions (mean ±SD) occurred for ImPACT™: VRM (EFX 87.80 ±8.91, XFE 87.60 ±11.55, CO 85.97 ±10.23, P = .521, 1-β= .85), VSM (EFX 75.70 ±14.57, XFE 76.83 ±12.50, CO 72.90 ±15.19, P = .238, 1-β= .70), VMS (EFX 37.17 ±7.06, XFE 38.02 ±6.83, CO 37.69 ±6.90, P = .666, 1-β= .89), RT (EFX 0.552 ±0.05, XFE 0.560 ±0.05, CO 0.550 ±0.078, P = .598, 1-β= .87), IC (EFX 5.93 ±4.2, XFE 7.80 ±8.35, CO 5.60 ±3.23,P=.108,1-β=.61). **Conclusions**: Our results indicate cognition was not improved with the EFX® product. While most other studies have examined the effects of "performance technology" products on physical performance, our results are unique as they target variables of cognitive function. Our results do not support the positive testimonial claims but it should be noted no negative or hindered performance was demonstrated. Further investigation should be conducted to elucidate the influence of a "ceiling effect" with performance technology products.

The Ability of Instrument Assisted Soft Tissue Mobilization to Attenuate Inflammation and Symptoms of Muscle Damage after an Eccentric Exercise Protocol

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Context: It is common practice to incorporate manual therapy techniques; such as stretching, massage and soft tissue mobilization into treatment protocols for athletes suffering from symptoms of muscle damage following eccentric exercise(EE). A common treatment used for treatment of these symptoms is Instrument Assisted Soft Tissue Mobilization (IASTM). **Objective:** The purpose of this study was to determine the ability of IASTM to attenuate inflammation, and its effect on range of motion(ROM), pressure tolerance(PT) and 1 repetition max(1RM) after an EE protocol. **Design:** Repeated measures design. **Setting:**Research laboratory.**Participants:**Nine recreationally active, college aged males (18-24 years, 175.8±5.6cm, 73.3±14.9kg). **Interventions:**Subjects ROM was measured using a standard handheld goniometer, PT was measured using a handheld pressure algometer (Wagner Instruments, Greenwich, CT) the EEwas administered using a leg extension machine (Universal Weight Training, Inc., Cedar Rapids, IA). EE consisted of 7 sets of 10, single leg repetitions performed eccentrically at 120% of their 1RM. Twenty-four hours following the EE each subject received IASTM protocol (Graston Technique®, Indianapolis, IN) to the treatment leg (TL) while the other leg was used for the control leg (CL). **Main Outcome Measures:**The subject's ROM, 1RM and PT were measured at BL, 24, 48 and 72 hours followingEE. Muscle biopsies in the TL and CL were collected 24 and 48 hours following IASTM. Muscle samples were evaluated for inflammatory markers Interluekin- 6 (IL-6) and Tumor Necrosis Factor- (TNF-α) using Western Immuno-blotting. **Results:**Subjects ROM was significantly greater ($p<0.05$) in the TL (129.67±15.7 and 128.2±17.7 degrees) compared to the CL (117.8 ± 21.9, and 117.9±22.4 degrees) 24 hours and 48 hours following IASTM. There was no significant difference found for 1RM, PT, IL-6 or TNF-α between the TL and CL at similar time points. **Conclusions:**Though ROM was the only marker that significantly improved following IASTM, the mean 1RM was higher in the TL (87.8±19.2, 81.1±24.7 and 88.9±23.7 lbs) compared to the CL (78.9±18.3, 72.2±26.8, and 70.0±24.5 lbs) immediately following, 24 and 48hours after IASTM.These data indicate that a subject suffering from functional deficits, such as decreased ROM and decreased strength,would potentially benefit from IASTM treament.

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Context: Although some instruments have been validated for clinical measure of hydration status, new and currently invalid instruments are available for purchase and clinical use. Athletic trainers commonly use these instruments to assess hydration status for weight checks and body mass loss charts due to their ease of use. However, the validity of these popular instruments has not yet been established. **Ob-jective:** To determine the validity of urine specific gravity (USG) for the assessment of hydration status via the following instruments: handheld clinical refractometer, pen style digital refractometer, and midget urinometer as compared to the gold standard urine osmometer (OSMO). **Design:** De-scriptive diagnostic validity study. **Setting:** Biochemical research laboratory. **Patients or Other Participants:** Healthy active men and women (n=108; mean age=22±4yrs; self reported height= 174±20cm and mass= 75±17kg) were recruited among faculty and students on a university campus. **Interventions:** The independent variable was instrument type with four levels: osmometer, handheld clinical refractometer, pen style digital refractometer, and midget urinometer. After recruitment, participants completed an informed consent and a short health history questionnaire to rule out any exclusionary criteria such as kidney disease or chronic urinary tract infection. Participants were then given a clean standard urine cup and asked to provide as much sample as possible, providing more than one cup when possible. **Main Outcome Measures:** Hydration status was measured by USG and OSM. USG was evaluated by a handheld clinical refractometer, pen style digital refractometer, and midget urinometer. The gold standard OSM was calculated by a freezing point depression osmometer. Z scores were calculated for each instrument and Pearson product-moment correlation coefficients were evaluated to examine the relationship between each instrument of USG and OSM. **Results:** Strong significant correlations were identified for the digital refractometer ($r=0.814$, $p< 0.001$) and handheld clinical refractometer ($r=0.943$, $p< 0.001$) with OSM. A weak statistically insignificant correlation was established between the midget urinometer ($r=0.133$, $p< 0.142$) and OSM. Average hydration status indicated variability among some of the instruments: digital refractometer USG=1.0194±0.0075, clinical refractometer USG=1.020±0.007, urinometer USG=1.028±0.091, osmometer OSM=743±271) **Conclusions:** Handheld clinical refractometry can be used confidently for assessing hydration status as it shows a strong significant correlation with the gold standard osmometer, which is consistent with previous literature. Additionally, the use of the pen style digital refractometer showed a strong, significant correlation with the gold standard osmometer and provides clinicians with another option for the clinical assessment of USG and hydration status. The findings of this also study suggest that the use of a midget urinometer should be performed with extreme caution, as it showed a weak correlation with the gold standard osmometer, indicating it might not provide accurate results when used to determine hydration status.

Effects of Hyperthermia, Hypohydration, and Fatigue on Mood and Reaction Time in Two Environments

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Context: Limited research has evaluated combined effects of hyperthermia, hypohydration, and fatigue on cognition. **Objective:** Determine individual and combined effects of hyperthermia, hypo-hydration, and fatigue on profile of mood states (POMS) and reaction time (RT) during a scanning visual vigilance test. **Design:** Randomized controlled trial. **Setting:** Climate controlled chamber. **Patients or Other Participants:** Twelve males (Mean±SD: age=20±2y, height= 182±8cm, body mass=74.0±8.2kg, body fat=9±3%, VO_{2max}=57.0±6.0 mL $\cdot kg^{-1} \cdot min^{-1}$) volunteered for participation. **Interventions:** Participants completed four, 90-minute treadmill bouts (1.34-1.78m$\cdot s^{-1}$; 5% grade) followed by 60-minutes of quiet sitting under two hydration states and two environmental conditions: euhydrated temperate (EUT), hypo-hydrated temperate (HYT), euhydrated hot (EUH), hypohydrated hot (HYH). Temperate and hot conditions were performed in 18±0.2ºC, 50±3.5%RH, and 34±0.3ºC, 45±4.5%RH, re-spectively. Hypohydration consisted of 22-hour fluid restriction prior to the trial and during the trial, while euhydration consisted of consuming oral fluids *ad libitum* the day prior to the trial and equal to the subject's sweat rate during the trial. Outcome measures were recorded prior to the exercise bout (PRE), immediately following the exercise bout (POST), and immediately following 60-minutes of recovery (REC). POMSdata were analyzed via one-way repeated

measures ANOVA, and RT data were analyzed via two-way (condition X time) repeated measures ANOVA and Tukey post-hoc tests.Significance was set *a priori* at p<0.05.**Main Outcome Measures:** POMS and RT. **Results:** Significant change scores for POMS from PRE to POST included: "total mood dis-turbance" was higher in HYHcompared to EUT, HYT, and EUH (35±21 vs. 3±10, 3±16, 16±26, respectively; p<0.001), "fatigue-inertia" was higher in HYH compared to EUT and HYT (13±4 vs. 3±3 and 4±5, respectively; p=0.004), "confusion-bewilderment" was higher in HYH compared to EUT and HYT (5±5 vs. 0±2 and 0±3, respectively; p<0.001), and "depres-sion-dejection" was higher in HYH compared to HYT (6±7 vs. -1±3; p=0.004). Significant change scores for POMS from PRE to REC included: "fatigue-inertia" was higher in HYH compared to EUT, HYT, and EUH (10±3 vs. 2±3, 3±5, 3±7; p<0.001) and "total mood disturbance" was higher in HYH compared to HYT (18±18 vs.-3±20; p=0.004). No significant change scores were observed POST to REC(p>0.05).A significant time main effect occurred for RT (p=0.002). RT was slower at POST compared to PRE (p<0.001) and REC (p=0.041). No significant difference occurred between PRE and REC (p>0.05). **Conclusions:** Combined effects of hypohydration and hyperthermia had additive negative effects on changes in mood state after exercise. In addition, 90-minutes of exercise resulted in slower RT regardless of hydration state and environmental condition; however these negative effects subsided after 60 minutes of recovery. Therefore, it appears that fatigue had the greatest effect on RT and could potentially increase the risk of injury in athletes.

Sweat Rate and Sweat-Electrolyte Composition in Athletes with Recurrent Cramping Versus non-Cramping Matches

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Context: There are currently two prevailing theories on the cause of exercise-associated muscle cramps (EAMC); neuromuscular fatigue and electrolyte depletion. Particularly, electrolyte depletion research has focused on sodium losses increasing EAMC risk. **Objective:** The purpose of this study was to compare sweat rate and sweat electrolyte concentrations in EAMCprone (EP) athletes to matched controls (MC).**Design:** Cross-sectional case control. **Setting:** Observational. **Patients or Other Participants:** Twenty-six male physically active subjects (21 ± 8y, 97.1 ± 19.6kg, 14.1 ± 3.4% body fat) voluntarily partici-pated. Each EP was matched with a MC according to age, body mass,% body fat, gender, sport, position, and heat-acclimatization. **Interventions:** Participants completed a scheduled workout or practice. Pre- and Post-exercise body mass were assessed using a standard scale and subsequent sweat rate was calculated. Standard sweat patch collection and ion-specific electrolyte analysis were used to quantify sweat electrolyte concentrations. **Main Outcome Measures:** Sweat rate, sweat [Na^+], sweat [K^+], sweat [Cl^-].**Results:** EP was matched to MC with no significant differences in age, body mass or body fat % (p>.05). Sweat rate was not significantly different between EP (2.09 ± 0.97$L \cdot h^{-1}$) and MC (1.81 ± 0.77$L \cdot h^{-1}$; p=.433). Sweat [Na^+] (EP: 48.58 ± 26.58$mEq \cdot L^{-1}$ vs MC: 30.01 ± 20.36 $mEq \cdot L^{-1}$; p=.057), sweat [K^+] (EP: 5.66 ± 0.84$mEq \cdot L^{-1}$ vs MC: 6.30± 1.50 $mEq \cdot L^{-1}$; p=.212), and sweat [Cl^-] (EP: 38.87 ± 23.97$mEq \cdot L^{-1}$ vs MC:24.01 ±18.7$mEq \cdot L^{-1}$; p=.091) were not significantly different between groups. Receiver operator characteristic analysis identified a cut point of ≥30$mEq \cdot L^{-1}$ as a high sweat [Na^+] and ≥24$mEq \cdot L^{-1}$ as a high sweat [Cl^-].Fisher's Exact Test demonstrated a statistically significant difference in frequency of high sweat [Na^+] and sweat [Cl^-] between groups (1-sided p=.008). These values demonstrated identical 0.77 (CI: 0.50-0.92) sensitivity and 0.77 (CI: 0.50-0.92) specificity in predicting EP athletes. This represented a diagnostic odds ratio of 11.1 (CI: 1.8-68.9) for both sweat [Na^+] and sweat [Cl^-]. **Conclusions:** Our data suggests that increased sweat [Na^+] and sweat [Cl^-] predispose athletes to EAMC. Sweat rate and sweat [K^+] appear less predictive in classifying athletes as EP. Patients with repeated episodes of EAMC warrant sweat-electrolyte analysis and/or NaCl supplementation to prevent cramping.

Serum Creatine Kinase Levels in NCAA Football Players During Preseason Now that an Acclimatization Time Period is Mandated

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Context: One consequence of practicing football during pre-season in warm, humid environments is rhabdomyolysis, as documented by elevated serum creatine kinase (CK). CK was measured in collegiate football players during the first 10 days of pre-season two-a-day practices prior to the NCAA mandating an acclimatization time period in 2003. This study found CK levels of 5125 ± 5518 $U \cdot L^{-1}$ in the morning of the 4th day and 3370 ±3660 $U \cdot L^{-1}$ in the morning of the 7th day, which were significantly elevated from baseline measures (204 ± 67 $U \cdot L^{-1}$). **Objective:** To determine if partici-pation in pre-season football practices results in elevated serum CK now that the NCAA mandated a 5-day acclima-

tization period. An additional goal was to evaluate the influence of body mass index (BMI) on serum CK levels. We hypothesized that serum CK would increase over the course of the ten days of training camp, especially after the start of two-a-day practices. **Design:** Observational Cohort Study. **Setting:** Data was collected at an NCAA Division II University during training camp in August. **Patients or Other Participants:** Twelve NCAA Division II football players volunteered for participation (age: 22.1±.9y, mass: 101.8±20.5kg, height: 182.3±4.7cm, BSA: 3.33±.17m^2, BMI: 30.4±5$kg \cdot m^{2\text{-}1}$). **Intervention:** Eight cc of blood was drawn from an antecubital vein the day before the 1st preseason practice (baseline) and again on the morning of the 4th, 7th and 10th day. After clotting, the blood was spun on-site and the serum was separated, placed in cryovials and refrigerated until assay. Subject height and weight were obtained at baseline to calculate BMI. A one-way ANOVA was used to assess for differences in CK over time and Pearson's correlation was used to determine if there was a relationship between BMI and CK. **Main Outcome Measures:** Serum CK levels and BMI. **Results**: Compared to baseline (299±205 $U \cdot L^{-1}$), serum CK was significantly higher on day 4 (1497±1098 $U \cdot L^{-1}$,P<.05), day 7 (1773±10981405 $U \cdot L^{-1}$,P<.01) and day 10 (1463±1074 $U \cdot L^{-1}$,P<.05), but did not differ between days 4, 7 and 10. No correlation was found between BMI and serum CK (P=0.41). **Conclusion:** Serum CK was significantly elevated (on day 4) during the 5-day acclimatization period in collegiate football players, and remained elevated in the morning of the 7th and 10th day. However, compared to results from similar data collection prior to the NCAA mandated acclimatization period, CK was substantially lower (by 71% on day 4 and 47% on day 7). Although results indicate that rhabdomyolysis still occurs in collegiate football players during pre-season, the magnitude was less compared to data prior to the 2003 acclimatization guidelines. Of note, the highest CK values the morning of Day 7 followed the first day of twice-a-day practices (one with full contact) on day 6.

Influence of Lean Mass on Lower Extremity Energetic Capabilities during Landing

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Context: Less lean mass relative to total body mass may limit one's ability to produce adequate muscle torques to safely control landing from a jump, thus increasing the risk for injury. As less strength has been implicated as a factor in greater landing stiffness and reduced energy absorption capabilities in females, it remains unknown whether the underlying influence of available lean mass drives these relationships and in part, explains commonly observed sex differences in landing mechanics associated with injury risk. **Objective**: To determine the effect of lower extremity lean mass (LELM) and maximal eccentric thigh muscle strength capabilities on lower extremity energy absorption (EA) strategies during landing. We expected that LELM would be a significant positive predictor of EA and that these relationships would be mediated by eccentric strength. **Design**: Descriptive Cohort. **Setting**: Controlled Laboratory. **Patients or Other Participants**: 35 female (1.67±0.1m, 65.3± 6.6kg, 21.6± 3.6yrs) and 35 male (1.78±0.1m, 74.7±8.9kg, 20.9±2.9 yrs) athletes. **Interventions**: Participants were assessed for LELM using dual-energy x-ray absorptiometry, maximal eccentric quadriceps and hamstring strength with an isokinetic dynamometer at 180 deg/s, and lower extremity biomechanics during a drop jump landing task. **Main Outcome Measures:** LELM (%) and peak eccentric quadriceps (QuadECC; Nm*kg-1) and hamstring (HamECC; Nm*kg-1) torques were normalized to body mass. Normalized EA (J*N-1*m-1) for the hip (HEA), knee (KEA), and ankle (AEA), as well as total (hip + knee + ankle) EA (TEA) were calculated from the kinematic and kinetic data during the initial deceleration phase of the drop jump landing. Linear regressions examined the extent to which LELM predicted each EA variable within sex. A mediation analysis using a non-parametric bootstrapping procedure then examined whether these relationships were mediated by QuadECC and HamECC. **Results:** Means±SD were 23.6±2.9 and 29.1±2.3% (LELM), 15.0±2.7 and 17.3±2.6J*N-1*m-1 (TEA), 2.7±1.3 and 3.9±1.7J*N-1*m-1 (HEA), 9.1±2.6 and 9.8±2.6J*N-1*m-1 (KEA), 3.1±1.4 and 3.7±1.2J*N-1*m-1 (AEA), 3.2±0.5 and 3.9±0.7Nm*kg-1 (QuadECC), and 2.0±0.3 and 2.5±0.3Nm*kg-1 (HamECC) for females and males, respectively. LELM was a significant predictor of KEA (R2= 0.136, p=0.02) in females, but not in males (R2= -0.028; p=0.81). QuadECC was a significant mediator of the effect of LELM on TEA for females (ab= 0.177, 95% C.I.= [0.01, 0.42]), but not for any individual joint. HamECC was a significant mediator of the relationship between LELM and HEA in females (ab= 0.208, 95% C.I.= [0.07, 0.41]). No significant relationships were observed in males. **Conclusions:** LELM was a more important determinant to energy absorption capabilities for females; however, maximal eccentric strength mediated the relationship only with TEA. Neither LELM nor maximal eccentric strength predicted landing energetics in males. More work is needed to investigate the underlying sex-specific mechanisms which determine energy absorption capabilities and the associated implications for ACL injury risk.

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Quadriceps Strength is Associated with Knee Flexion Angles and Moments During Dynamic Landing Following Anterior Cruciate Ligament Reconstruction

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Context: Maximizing quadriceps function following anterior cruciate ligament reconstruction (ACLr) is a challenge for clinicians and patients alike. Quadriceps weakness often persists following rehabilitation and is considered to influence knee mechanics during walking gait. Little is known, however, about the relationship between quadriceps strength and knee mechanics during dynamic sport-like movement post-ACLr. As many individuals return to activity following ACLr, it is important to identify whether quadriceps strength influences knee mechanics during sport-like activity. **Objective:** To determine the relationship between quadriceps strength and knee mechanics during a single-leg landing task post-ACLr. **Design:** Descriptive laboratory study. **Setting:** University Laboratory. **Patients or Other Participants:** Twenty-four individuals (14 male, 10 female; age: 19.38± 5.40yrs; height: 1.76±0.09m; mass: 74.87±11.73kg) post-ACLr (7.6±1.36 mo) were tested upon being cleared to return to activity. **Interventions:** Three-dimensional knee biomechanics were recorded during a single-leg land-and-cut maneuver. Isokinetic quadriceps strength was assessed using a dynamometer at 60°/second. **Main Outcome Measures:** Peak stance sagittal plane kinematics and kinetics were calculated using a standard inverse dynamics approach. Kinetic outputs were normalized to subject body mass and height and represented as external moments. Three maximal knee extension trials

were averaged and normalized to subject body mass to quantify quadriceps strength. Linear regressions were used to examine the relationship between quadriceps strength and knee moments and quadriceps strength and knee angles. **Results:** Quadriceps strength was found to be associated with knee flexion moments (R^2=0.320, *b*=0.445, P=0.004) and angles (R^2=0.247, *b*= -12.633, P=0.013). **Con-clusions:** Our results suggest that greater quadriceps strength is associated with larger knee flexion angles and torques during a single-leg landing. Specifically, when normalized quadriceps strength increased by 1 Nm/kg, knee flexion moments increased by 0.45 Nm/kg*m and knee flexion angles increased by 12.6 degrees. These results reinforce the importance of maximizing quadriceps strength post-ACLr, and help to provide evidence that quadriceps strength, in part, contributes to alterations in knee mechanics during a sport-like maneuver. Supported by NIH Grant K08 AR053152-01A2 and the University of Michigan's Rackham School of Graduate Studies.

Biomechanical Differences Exist in the Injured and Uninjured Limb of Individuals with Prior Meniscal Injury

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Context: Meniscal injuries are a primary risk factor for early onset knee osteoarthritis, leading to a lifetime of pain and dysfunction. Asymmetrical lower extremity biomechanics have been identified following other knee injuries that potentially contribute to poor outcomes and progression of osteoarthritis post injury. However, the effects of isolated meniscal injury on lower extremity biomechanics are unknown. **Objective:** To examine the effect of prior meniscal injury on lower extremity biomechanics during a double leg jump-landing task. **Design**: Cross-sectional. **Setting**: Research laboratory. **Participants**: 5,919 healthy physically active participants were enrolled in this study and a total of 5,333 (3,237 males, 2,096 females) were included in this analysis. Those with prior meniscal injuries (MEN) (n=99, age=18.88 ±1.04years, height =173.82±9.08cm, mass= 74.00 ±13.64kg) and those with no prior history of knee related injury (CON) (n=4,893, age=18.73±0.90 years, height=173.08±9.17cm, mass= 71.30 ±12.43kg) at the time of testing were identified using a self-report questionnaire. **Interventions**: Kinematic and kinetic data were collected during three double leg jump-landing trials using an electromagnetic motion capture system and forceplate. All measures were collected on the participant's dominant kicking leg. The MEN group was subdivided into those instrumented on their injured limb (INJ) or uninjured limb (UNINJ) for analyses. **Main Outcome Measures**: Three-dimensional hip and knee joint angles, three-dimensional internal knee joint moments, and vertical ground reaction force (VGRF) values were identified at the following time points of the jump landing task; 0%, 15%, 50% and 85%. These time points correspond to initial contact, weight acceptance, maximal knee flexion and ascent phases of the jump-landing task. Separate mixed-model repeated measures ANOVA were performed to compare the biomechanical variables between groups (MEN, CON) across each time point of the jump-landing task (0%,15%,50%,85%). Post-hoc analy-ses involved independent samples t-tests with a Bonferroni correction ($\alpha \leq 0.0125$). **Results**: Significant differences between the MEN and CON group were identified in the uninjured limb. Specifically, the uninjured limb of the MEN group displayed greater knee flexion at 50% of stance (MEN=97.31±18.73; CON= 81.66± 13.91,p=.007) and greater hip flexion at 15% (MEN=-69.25±8.69, CON=-90.72±15.51, p=.006) and 50% of stance (MEN=-53.36±14.23 and -67.29±20.81, *p*=.006) compared to the CON group. The injured limb displayed a significant group-by-time interaction for VGRF (p=.04), however post-hoc testing was non-significant (*p*=.015). Results suggest a trend toward greater VGRF in the injured limb of the MEN (1.42±.72) compared to CON group (1.27±.55). **Conclusions**: Our findings indicate that individuals with prior meniscal injury utilize greater hip and knee flexion on the uninjured limb during a jump-landing task in comparison to healthy controls. Traumatic meniscal lesions typically occur in young active individuals who wish to return to sport following injury; therefore identifying and improving potential compensations after meniscal injury may be an important component in preventing future injury and delaying the onset of osteoarthritis. Funded by the NIAMS Division of the National Institutes of Health, #RO1-AR050461001.

Effect of Playing Surface on Hip and Knee Kinematics in Healthy Female Soccer Players

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Context: Playing surface is thought to alter lower extremity kinematics and influence the risk of noncontact anterior cruciate ligament (ACL) injury. However, there has been limited research examining the effect of playing surface on hip and knee kinematics. **Objective:** To determine if hip and knee kinematics during a jump landing cutting task differ between 3rd generation artificial turf and natural grass playing surfaces in unimpaired females. **Design:** Repeated measures design. **Setting:** Sport practice fields. **Participants:** Twenty-seven female Division I varsity and club soccer athletes (17 varsity, 10 club; age = 20.0±1.4 years; height = 167.5±6.5 cm; mass = 65.2±11.1 kg;

years playing competitively = 11.6 ±3.3years). **Interventions:** Participants performed a 90° cutting maneuver immediately after landing from a box jump on natural grass and 3rd generation artificial turf. Hip and knee kinematics were assessed using an electromagnetic motion analysis system. Force sensitive resistors placed in the shoe were used to define initial ground contact. **Main Outcome Measures:** Hip and knee kinematics in all three planes of motion were assessed at initial contact and peak knee flexion of landing. Excursion was calculated as the angular change from initial contact to the time corresponding with peak knee flexion. Values were averaged across trials for each surface condition. Paired samples t-tests were used to compare joint angles at initial contact and peak knee flexion, as well as excursion values, between conditions. The significance level was set a priori at an alpha of 0.05. **Results:** Joint angles at peak knee flexion and excursion values differed significantly between surfaces. Specifically, participants showed greater hip adduction (Grass: -3.2±6.6, Turf: 0.8± 7.0; P = 0.005) and less hip external rotation (Grass: -5.6±8.2, Turf: -2.7±7.7; P = 0.007) on artificial turf at peak knee flexion, while exhibiting greater excursion in the frontal plane at the knee on grass (Grass: 9.0±7.4, Turf: 6.5±5.1; P = 0.050). There was no difference between surfaces at initial contact (P > 0.05). At peak knee flexion, there was no difference at the hip in the sagittal plane (P > 0.05) and at the knee (P > 0.05). Excursion values showed no difference at the hip (P > 0.05) and at the knee in the sagittal (P > 0.05) and transverse (P > 0.05) planes. **Conclusions:** Playing surface significantly affected hip and knee kinematics in this sample of female soccer players. Nevertheless, these findings did not support our expectations that the hip and knee would adopt a position of increased ACL loading while on artificial turf. However, future studies should address the clinical importance of these findings and their influence on the risk for noncontact ACL injury. Such work is important to determine the optimal playing surfaces for practices and games to minimize noncontact injuries.

Comparative Dynamic Balance, Pain and Neuromuscular Responses Among Therapeutic Patellofemoral Taping Techniques

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Context: Nonoperative treatment of patellofemoral dysfunction (PFD)is commonly considered the typical standard of care for symptomatic patients. Previous research has shown that patellofemoral taping techniques improve quadriceps function and pain. However, limited evidence exists comparing the effectiveness of different taping techniques. **Objective:** To compare dynamic balance, pain and neuromuscular responses in physically active patients diagnosed with acute unilateral PFD after undergoing two different therapeutic taping techniques. We hypothesized that taping conditions would yield improved outcomes compared to no tape. **Design:** Retrospective cohort (2b evidence). **Setting:** Controlled laboratory. **Patients or Other Participants:** Twenty (7 men and 13 women) patients (age = 21.2 ± 2.9 years, height = 1.69 ± 0.2m, mass = 68.11 ± 11.6kg, Tegner = 6.25 ± 1.3, Kujala = 78.9 ± 9.38). Patients with history of traumatic injury to either lower extremity were excluded. **Interventions:** Patients underwent one bilateral baseline testing session and two unilateral taping (McConnell medial glide and NUCAP Medical Upper Knee Spider®) sessions. Forty-eight hours separated sessions. Randomization was used to prevent order effects. **Main Outcome Measures:** Knee taping condition was the independent variable. Dependent variables included single-leg balance reach distances as well as pain and quadriceps neuromuscular activity during the balance task. Reach distances were normalized to leg-length (% LL). Pain was gauged via a standard visual analog scale measured in centimeters (cm). Quadriceps neuromuscular activity was nor-malized to maximal volitional isometric contraction (%MVIC). One-tail paired t-tests were calculated to determine bilateral baseline statistically significant differences. One-way analyses of variance with Tukey's post hoc test was calculated to determine statistically significant differences among knee conditions (baseline, McConnell and Spider®) for the involved leg. $P \leq 0.05$ denoted statistical significance. **Results:** Data met assumptions for statistical analyses. Lesser baseline reach distances were recorded for the involved (72.14 ± 6.0 %LL) compared to uninvolved (74.14 ± 6.0 %LL) leg (P =0.014). Patients displayed increased reach distances with the involved leg under McConnell (75.65 ± 7.3 %LL, P =0.002) and Spider® (75.39 ± 6.5 %LL, P = 0.005) conditions compared to baseline (72.14 ± 6.0 %LL).Pain also decreased under McConnell (1.16 ± 1.2cm,P = 0.001) and Spider® (1.04 ± 1.03cm, P = 0.001) conditions compared to baseline (1.95 ± 1.4cm). Vastus medialis activation increased under the McConnell condition (17.63 ± 7.6 %MVIC) compared to baseline (14.68 ± 7.8 %MVIC, P =0.015). Furthermore, there was a difference in vastus medialis activation between McConnell (17.63 ± 7.6 %MVIC) and Spider® (14.36 ± 8.2 %MVIC) condition (P=0.026). Other comparisons were statistically insignificant. **Conclusion:** Our findings suggest both McConnell and Spider® taping techniques improve outcome measures in acute PFD patients. However, further research is warranted to investigate the efficacy of such interventions.

Deficits in Jump Landing Mechanics After ACL Reconstruction

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Context: Anterior cruciate ligament (ACL) injuries are one of the most common knee injuries in sport. For those able to return to sport, up to 25% will experience a second ACL injury in either the ipsilateral or contralateral limb. Post-reconstruction landing force adaptations and clinical movement assessments may provide insight as to why second ACL injury rates are so high. **Objective:** To determine if (1) peak vertical ground reaction forces (VGRF) differs between limbs and groups (ACL reconstructed (ACLR) vs. controls), (2) Landing Error Scoring System (LESS) score and VGRF index differ between groups, and (3) determine if a relationship exists between LESS score and VGRF index. **Design:** Cross-sectional. **Setting:** Laboratory. **Patients or Other Participants:** Thirteen volunteers with unilateral ACLR(170.5±4.0cm, 70.7±11.4kg, 19.2±1.4yrs) and 14 healthy controls (166.5±7.5cm, 64.7 ±8.2kg, 20.3± 1.7yrs). **Interventions:** All individuals completed 3 trials of a jump landing off a 12 inch high box placed 50% of their height from force plates. Participants jumped forward off the box, landed on the plates, and immediately jumped for height. Force plates recorded VGRF and standard video cameras recorded frontal and sagittal plane views during landings. Videos were reviewed and paused at different time points to assess lower extremity postures using standardized LESS scoring criteria. **Main Outcome Measures:** Peak VGRF was normalized to body weight (BW). Limbs were matched between groups such that the involved and uninvolved limbs in the ACLR group were matched to dominant and nondominant limbs in the control group, respectively.A VGRF limb symmetry index (%LSI) was created (involved limb/uninvolved limb x 100). The individual com-ponents of the LESS were graded and summed to create the total LESS score. A group (2-levels) by limb (2-levels) repeated measures ANOVA was used to analyze VGRF and post-hoc testing was performed if necessary. Independent samples t-tests were used to compare LESS score and VGRF index between groups.A pearson correlation coefficient was computed between LESS score and VGRF index (α<0.05).**Results:** A significant interaction (P=.03, $F_{(1,25)}$=5.2) was observed for VGRF.Tukey post hoc testing revealed the uninvolved limb in the ACLR group had greater VGRF compared to the involved limb (Uninvolved: 2.3±.6BW, Involved: 1.9±.6BW) and both limbs in the control group (Dominant: 1.9±.4BW, Nondominant: 1.9±.3BW). The ACLR group had higher LESS score (ACLR: 6.5±1.9errors, Control: 4.6±1.4errors, P=.007, $t_{(1,25)}$=-2.9) and lower VGRF index (Control: 104.8±22.3%LSI, ACLR: 85.7±15.4%LSI, P=.02, $t_{(1,25)}$= 2.6) compared to controls. LESS score and VGRF index had a negative relationship (r=-.39, P=.04). **Conclusions:** ACLR individuals land asymmetrically and have worse body control. ACLR individuals have difficulty controlling the lower extremity during high risk landing maneuvers even after completion of a rehabilitation program. Interventions to address these issues could lower second ACL injury rates. Funding: UW Sports Medicine Research Fund.

Immediate Effects of Real Time Feedback During Jump-Landing on the Landing Error Scoring System

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Context: Suboptimal lower extremity biomechanics during jump-landing may lead to various lower extremity joint injuries. Clinician provided feedback has been used previously to positively alter landing biomechanics, yet the use of technology in an effort to allow for the participant to make instantaneous biomechanical adjust-ments during landing has not been evaluated. **Objective:** Determine the immediate effects of real time feedback (RTF) and traditional verbal feedback (TF) interventions on Landing Error Scoring System (LESS) scores compared to a control condition. **Design:** Single Blinded, randomized controlled trial. **Setting:** Research laboratory. **Patients or Other Participants:** Twenty-four physically active female participants with no history of lower extremity injury volunteered and were ran-domized into 3 groups (RTF: n=8, age=21.0±1.4yrs, height=164±5.1cm, mass=65.1±8.2kg; TF: n=8, age= 20.9±2.1yrs, height=165±5.2cm, mass=61.6±3.4kg; Control: n=8, age =22.7±3.5yrs, height=166.6±6.2cm, weight=68.6±14.2kg). **Inter-ventions:** All participants completed three sets of six jump-landing trials (18 total) off a 30cm box. Participants in the RTF and TF groups were provided standardized feedback, using verbal cues and visual representation of correct landing biomechanics, from a single clinician before each set of jumps. Participants in the RTF group were equipped with retroreflective markers positioned on the lower extremity. Using Cortex software and 3-dimentional Motion Analysis, markers on the middle of the patella and the dorsum of the great toe of the right limb were highlighted in color, and connected with a segment line. RTF participants were able to visualize their 3-dimensional model on a 107cm monitor, and were instructed to align the highlighted knee-foot segment with a stationary vertical reference line in the frontal plane during landing. Control participants received no feedback while performing the 18 box jumps. **Main Outcome Measures:** All participants performed the LESS testing protocol at baseline and immediately following the inter-vention, consisting of a forward jump off a 30cm box transitioning into a

maximal vertical jump. Trials were recorded in the frontal and sagittal planes using two-dimensional video and evaluated with the LESS scoring criteria by two blinded independent assessors. Delta scores from baseline were calculated for all three groups. Independent t-tests and effect sizes (Cohen's *d*) were performed to assess change scores in the LESS for specific comparisons (TF v. control; RTF v. control). Alpha was set at P<0.05 a priori. **Results:** LESS score did not significantly change following TF (-0.63±2.5) compared to control (0.57±1.8; t_{14}=-1.05, P=0.32, *d*= -0.54, 95% confidence interval: -1.54 to 0.52). LESS scored decreased significantly following RTF (-1.37 ±1.5) compared to control (0.57±1.8; t_{14}=-2.27, P=0.04, *d*=-1.2, -2.22 to -0.4). **Conclusion:** RTF decreased LESS score and had a strong effect for immediately improving LESS score compared to the control. TF showed no immediate effect. Further study is warranted to determine the clinical impact of the addition of RTF in making biomechanical corrections during landing.

Influence of Hip Strength and Range of Motion on Medial Knee Displacement in High School Athletes

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Context: Medial knee displacement, or dynamic knee valgus, is often reported as a possible risk factor for anterior cruciate ligament (ACL) injury and patellofemoral pain syndrome. Knowledge about contributing factors for medial knee displacement (MKD) is limited, especially in an adolescent population. **Objective:**To determine if sex, lower extremity muscle strength and flexibility predict MKD. **Design:** Cross-sectional. **Setting:**High School. **Patients or Other Participants:**Thirty-eight males (Age= 16±1yrs, Mass= 69.4±13.4kg, Height =177.5±10.7cm) and twenty-eight females (Age= 16±1yrs, Mass= 58.4±6.6kg, Height= 164.3± 7.2cm) volunteered to participate in this study. **Interventions:**Participants completed three trials of a standardized jump landing task that required them to jump forward from a 30-cm high box a distance of half their height and jump for maximal vertical height immediately upon landing. An electromagnetic motion analysis system and force plate collected three-dimensional lower extremity kinematics and ground reaction forces during the jump landing task. Isometric strength of the hip abductors, gluteus maximus, hip internal rotators andhip external rotators was assessed using a hand-held dynamometer. A digital inclinometer was used to evaluate hip abduction, hip internal rotation, and hip external rotation range of motion. Two trials of each flexibility and strength measure were recorded. **Main Outcome Measures:** Medial knee displacement was measured as the knee joint center displacement between initial contact (ground reaction force>10N) and maximum knee flexion. The average value for MKD, and the strength and range of motion measures was used for the analyses. Pearson correlation coefficients were calculated to evaluate the relationship between sex, the flexibility and strength measures and MKD. A stepwise linear regression was performed to determine the influence of sex, lower extremity strength, and flexibility on MKD ($\alpha \leq .05$). **Results:** Decreased hip abduction strength (r= -0.23, p=.03), decreased gluteus maximus strength (r=-0.25, p=.02), greater hip internal rotation range of motion (r=0.23, p=.03) and greater hip abduction range of motion (r=0.28, p=.01) were significantly correlated with greater MKD displacement. Greater hip abduction range of motion and decreased gluteus maximus strength significantly predicted greater MKD displacement (R^2=0.16, p=.004). **Conclusions:**Medial knee displacement appears to be partly explained by gluteus maximus weakness and greater hip abduction range of motion. These findings suggest that other factors, such as poor neuromuscular control, may be more important than strength and flexibility for predicting medial knee displacement in adolescents.

Assessment of Muscle Activation Between Genders During a Drop Jump Task with an External Motivator

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Context: Females are 6-8 times more likely to suffer a non-contact ACL injury than males competing in the same activities. Non-contact ACL injuries are common in sports that involve jumping, cutting, rapid deceleration, and/or quick changes in direction. Literature is limited on pre- and post-landing muscle activation among gender during a functional drop jump followed by another task (external motivator). **Objective:** The purpose of this study was to examine muscle activation pre- and post-landing between genders during a functional drop jump with an external motivator (target height). **Design:** A comparison design was used to assess muscle activation differences between genders. **Setting:** Bio-mechanics laboratory. **Patients or Other Participants:** Twenty eight healthy physically active participants were recruited to participate in this study. Fourteen males (22±3yrs, 78.8±7.6kg, 78.5±4.8cm) and females (22±2yrs, 66.7±7.8kg, 65.0±5.2cm) were matched according to gender and leg dominance. Leg dominance was defined as the plant leg during kicking. **Interventions:** Drop jump landings with an external motivator were performed from a 30cm box onto a force platform followed by an immediate jump to reach for the target height on the external motivator that was placed anterior/lateral at a

40°angle from the force platform. This set-up replicated a common mechanism of injury for non-contact ACL injuries. The target height was 75% of the participants' maximal vertical jump. **Main Outcome Measures:** The dependent variable was muscle activation. Muscle activation was measured using the Myomonitor IV (Delsys, Boston, MA). Mean and peak normalized muscle activation of the transverse abdominus and internal oblique (TrA/IO), rectus abdominus (RA), vastus lateralis (VL), biceps femoris (BF) and gluteus medius (GMed) were assessed. Muscle activation was assessed before (100ms) and after (250ms) initial contact. Maximal voluntary contractions were used to normalize muscle activation data. Independent t-tests were used to compare differences in muscle activation between gender (pre-initial contact and post-initial contact). **Results:** No differences were observed in mean (TrA/IO- p = 0.184; RA- p = 0.894; VL- p = 0.985; BF- p = 0.973; GMed- p = 0.661) & peak (TrA/IO- p = 0.389; RA- p = 0.829; VL- p = 0.424; BF- p = 0.671; GMed- p = 0.949) muscle activation before landing. Differences were not observed in mean (TrA/IO- p = 0.352; RA- p = 0.998; VL- p = 0.527; BF- p = 0.916; GMed- p = 0.820) & peak (TrA/IO- p = 0.344; RA- p = 0.903; VL- p = 0.196; BF- p = 0.824; GMed- p = 0.674) muscle activation following initial contact. **Conclusions:** This data contradicts previous research that reported gender differences in muscle activation during a functional task. It appears that an external motivator may influence a patient's muscle recruitment and may be a factor to include in injury prevention programs.

Variability of Postural Control is Not Affected by Previous ACL Injury

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Context: Previous research indicates differences in postural control exist following ACL injury and reconstruction (ACLR). Measures of variability may be more sensitive to differences that exist in postural control following ACL injury. **Objective:** To determine if individuals with ACLR display differences in the variability of postural control between limbs and as compared to healthy controls. **Setting:** Sports Medicine Research Laboratory. **Participants:** Fifty-two physically active individuals participated in this study, 18 with a history of ACL injury and ACL reconstruction (ACLR Group: Males = 11, Females = 7; Height = 71.56±8.68 cm, Mass = 74.66±10.34 kg) and 34 healthy controls with no history of ACL injury or reconstruction (CON Group: Males = 16, Females = 18; Height = 171.11± 10.09 cm, Mass = 73.22±14.23 kg) **Interventions:** All participants performed single-leg balance atop a force plate that recorded center of pressure (CoP) trajectories. The task was performed bilaterally, and two, twenty second trials were performed for each leg. A trial was considered successful if the participant was able to complete the task without raising their hands off their hips, without touching down with the non-test leg, and did not lift the foot of their test leg off of the force plate. **Main Outcome Measures:** The variability of the CoP trajectory in the anterior-posterior (AP) and medial-lateral (ML) direction was quantified using the nonlinear measure of Approximate Entropy (ApEn). ApEn quantifies the variability of a time series and is more sensitive to differences in postural control than traditional measures. A value closer to 0 indicates a more regular time series, and a value closer to 2 indicates a more random time series. Differences in variability of postural control for the AP and ML direction were determined using two 2x2 (Group x Leg) mixed model ANOVAs. Post-hoc analyses were performed for any significant main or interaction effects using Tukey's HSD (á£0.05). **Results:** The ACLR group demonstrated similar ApEn values between limbs in the AP (AP: INJ=0.85±0.12 UNINJ=0.92±0.14) and the ML (ML: INJ=1.17±0.13 UNINJ=1.15±0.14) directions. The CON group demonstrated similar values (AP: DOM=0.91±0.15 NONDOM=0.91±0.20) (ML: DOM= 1.17±0.14 NONDOM =1.18± 0.14). No significant differences were found for the main effect of Group (AP: p=0.60, ML: p=0.70), Leg (AP: p= 0.21, ML: p=0.95), or interaction effect of Group x Leg (AP: p=0.16, ML: p=0.23). **Conclusions:** Differences in the variability of postural control during single-leg balance do not exist in those with a history of ACL injury and reconstruction. Bilateral differences do not exist in healthy individuals either. Therefore, while previous research indicates postural control is affected by ACL injury, a lack of difference in variability may indicate that the ability to respond to internal or external perturbations is not. Funding for this study provided by the National Academy of Sports Medicine.

Sagittal Plane Ankle Displacement is Associated with Hip and Knee Internal Rotation Angle During Stair Descent in Females with Patellofemoral Pain

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Context: Limited passive ankle dorsiflexion range of motion is associated with patellofemoral pain (PFP). However, the mechanism by which limited ankle dorsiflexion range of motion may lead to PFP is not clear. Healthy individuals with increased medial knee displacement also demonstrate limited passive ankle dorsiflexion range of motion; however, research has not investigated ankle dorsiflexion motion during functional tasks or in those with PFP. **Objective:** To examine the relationship between ankle dorsiflexion displacement and hip and knee frontal and transverse plane kinematics during a stair descent task in females with PFP. **Design:** Cross-sectional correlational. **Setting:** Research laboratory. **Patients or Other Participants:** Twenty female volunteered for this study (20 PFP: Age= 22.2±3.1years, Ht= 164.5 ±9.2cm, Mass= 63.5± 13.7Kg). Inclu-sion criteria for PFP included the following: at least 2 months of anterior, lateral, or retro patellar pain during jogging, hopping, ascent and descent during stair climbing, kneeling, squatting, kneeling, and sitting for a long period of time with knee flexed, free from other lower extremity injuries within 6 months prior to the testing, and negative findings on examination of ligaments, menisci, bursa, and synovial plica. **Interventions:** All participants performed 3 stair descent trials at a standardized speed. Three-dimensional lower extremity kinematics were assessed using a 7-camera infrared optical motion capture system. Ankle dorsiflexion displacement was calculated as the difference between the joint angle at initial foot contact and the peak dorsiflexion during the stance phase. The stance phase was defined as the time from initial contact of the foot to toe off of the affected limb. Peak hip internal rotation (HIR), hip adduction (HAD), knee internal rotation (KIR), and abduction (KAB) angles were also measured during the stance phase. All dependent variables were averaged across the 3 trials. Pearson Product Moment Correlation Coefficients were calculated to identify the linear relationship between ankle dorsiflexion displacement and the other dependent variables in the PFP (α<0.05). **Results:** The participants with PFP demonstrated significant correlations between ankle dorsiflexion displacement and peak HIR (r=0.36, p=0.12) and KIR (-r= 0.50, p=0.02). However, there were no significant correlations with peak HAD (r=0.09, p=0.71) and KAB (r= 0.07, p=0.78). **Discussion**: Decreased ankle dorsiflexion displacement was associated with increased HIR and KIR in the participants with PFP. Excessive HIR has been associated with PFP by increasing lateral patellofemoral joint loading and KIR has been theorized to occur as a coupled motion with HIR. These findings suggest that limited ankle dorsiflexion motion may facilitate compensatory increases in HIR and KIR in those with PFP. Future research investigating interventions to increase ankle dorsiflexion displacement in those with PFP is warranted.

The Influence of Dorsiflexion on Dynamic Stability in Individuals with Chronic Ankle Instability

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Context: Deficits in ankle dorsiflexion and decreased reach distance in the anterior direction of the star excursion balance test (SEBT) have been documented separately in chronic ankle instability (CAI) patients. Previous findings have suggested that deficits in weight-bearing dorsiflexion (WB-DF) may negatively influence dynamic balance measured with the anterior reach distance of the Star Excursion Balance Test (SEBT) in individuals without ankle pathology; but it is unknown if this correlation exists in CAI patients. Additionally, assessing ankle dorsiflexion range of motion (ROM) using the weight-bearing lunge test (WBLT) to measure WB-DF has been suggested to be a viable alternative to open kinetic chain (OKC-DF) goniometric measurements of ankle dorsiflexion. However, there is little evidence to substantiate any correlation between the two measures. **Objective:** To determine if the anterior reach of the SEBT is correlated with WB-DF and OKC-DF in individuals with CAI; and to determine if the WB-DF measure is correlated with the OKC-DF measure. **Design:** Descriptive laboratory study. **Setting:** Research Laboratory. **Participants:** Ten participants with self-reported CAI (3M, 7F; 20.40± 1.78yrs; 167.27±9.16cm; 68.42± 14.67kg) volunteered. **Interventions:** Participants performed three trials each of the SEBT in the anterior direction, the WBLT, and active OKC-DF seated on a table with an extended knee. The SEBT and WBLT measures were performed using the injured limb of the participants. The OKC-DF measurement was performed with a bubble inclinometer attached to the dorsal surface of participant's foot. **Main Outcomes:** Three trials of the anterior reach of SEBT were reported as a percentage of limb length of the participant (%MAXD). The WB-DF measures were reported as the distance (cm) of the great toe from the wall without the heel lifting off the ground. OKC-DF was measured at the point of participant perceived maximum active dorsiflexion ROM (degrees). Individual means of three trials for each measure were used for analysis. Pearson product moment correlations were used to assess the relationship among dependent variables. Significance was set a priori at $P<0.05$. **Results:** WB-DF was significantly and moderately correlated ($r=0.626$, $R^2=0.390$, $p=0.026$) with %MAXD. OKC-DF was weakly correlated with %MAXD ($r=0.090$, $R^2=0.010$, $P=0.402$) as well as with WB-DF($r= 0.293$, $R^2=0.09$, $P=0.206$). **Conclusion:** We report a moderate correlation between the SEBT and the WBLT in participants with CAI, which is consistent with previous reports of similar comparisons among healthy subjects. Therefore, the amount of WB-DF availability on the WBLT appears to influence anterior %MAXD of the SEBT in CAI patients. We observed that OKC-DF measure was weakly correlated with anterior reach distance of SEBT and WB-DF measures. This suggests that WB-DF may not be related with OKC-DF. Perhaps the WB-DF may be more suitable for making comparisons with dynamic tasks such as the SEBT.

Lower Leg Anterior and Lateral Intracompartmental Pressure Changes Before and After Classic Versus Skate Nordic Rollerskiing in Collegiate Nordic Skiers

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Context: Increasing awareness of chronic exertional compartment syndrome (CECS) among Nordic skiers warrants the need for specific analysis of intracompartmental pressures (ICPs) before and after Nordic skiing. **Objective**: The purpose of this study was to determine if lower leg anterior and lateral ICPs are increased after a 20-minute Nordic rollerskiing time-trial, and to determine if a difference exists between post exercise ICPs for classic versus skate rollerskiing. **Design**: Mixed Factorial Repeated-Measures Design. **Setting**: Outdoor, paved exercise loop. **Patients or Other Participants**: Seven collegiate Nordic skiers with no history of knee, lower leg, or ankle surgery participated in the study (3 men, 4 women; age = 22.71 ± 1.38 yrs, height = 175.36 ± 6.33 cm, mass = 71.71 ± 6.58 kg). All partici-pants averaged 500-600 training hours per year, were registered with the International Ski Federation (FIS), had trained using both the classic Nordic skiing technique and skate Nordic skiing technique for at least the past 12 months, and had trained in the United States for at least 85% of the time over the past 12 months. **Interventions**: Independent variables were Nordic ski technique (classic and skate), gender (male or female), and time (pre exercise, 1-minute post-exercise, and 5-minutes postexercise). **Main Outcome Measures**: Anterior and lateral compartment ICPs (mmHg),

and lower leg pain were measured. **Results**: Results showed an increase in ICPs for all participants for both anterior and lateral compartments (p = 0.000 and p= 0.002, respectively), regardless of technique. A three-way interaction between time, technique, and gender was found for the anterior and lateral compartments and subjective per-ception of lower leg pain. The males showed statistical significance for the anterior ($t_{(6)}$ = 8.434, $p < 0.05$) and lateral ($t_{(6)}$ = 3.076, $p < 0.05$) ICPs between baseline and 1-minute post exercise when using the classic technique versus the skate technique. Although not statistically significant, the females showed higher anterior and lateral ICPs at 1-minute post exercise when using the skate technique versus the classic technique. The males' subjective perception of pain was statistically greater at 1-minute post exercise during classic rollerskiing versus skate rollerskiing, whereas the females' subjective perception of pain was statistically greater at 1-minute post exercise during skate rollerskiing versus classic rollerskiing. **Conclusions**: Our results suggest that Nordic skiing contributes to increases in ICPs which may lead to the development of CECS. Additonally, there may be a potential gender affect between the Nordic skiing techniques. This is the first study of its kind on Nordic skiing and CECS. These results help provide greater knowledge regarding the present phenomenon in which Nordic athletes commonly experience increases in the anterior and lateral compartments during ski activity, particularly during classic rollerskiing and skate skiing over icy snow.

Ankle Copers Exhibit a Heightened Sense of Force

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Context: Previous research has focused on sensory deficits after ankle sprains that originate from denervated capsuloligamentous tissue; however less attention has been directed towards the potential compensatory role of intact musculotendinous receptors. The capacity to perceive joint loads accurately and respond with adequate muscular tension is important to the dynamic restraint mechanisms and restoration of functional joint stability. While studies have suggested that force sense is impaired in subjects with functional ankle instability, no previous studies have investigated ankle "copers;" those patients who have sprained their ankle, but do not suffer from repetitive "giving way" events (functional instability). **Objective:** To investigate deficits in force sense in healthy, unstable ankles, as well as a group of copers. **Design:** Post-test only with comparison groups. **Setting:** University Laboratory. **Subjects:** 76 subjects (22.4±3.3yrs; 172.3±10.0cm; 72.9± 17.3kg) participated in this study. Subjects were stratified into three groups using the Cumberland Ankle Instability Tool (CAIT): controls (CON, n=20), unstable (UNS, n=19), copers (COP, n=19),. **Interventions**: Subjects were tested for pronation force sense at 30 and 50 percent of their maximum voluntary isometric contraction (MVIC) on a custom-built device. Subjects were allowed practice with visual feedback of force prior to the first trial, but no feedback was provided between trials. Subjects were instructed to exert their target torque, depress a hand-switch, and then hold the ankle at that torque for 2 seconds. **Main Outcome Measures:** Dependent variables included relative error [(matched torque-target torque)/ target torque, %], the variable error (standard deviation of relative error, %), time to matched force (s), and coefficient of variation of matched force (%). **Results:** A significant main effect of group was observed for variable error at 30% MVIC (F=4.47, p=0.01). Post-hoc tests revealed variable error was lower in both COP (11.7±7.9%, p=0.005) and UNS (15.0±8.8%, p=0.04) when compared to CON (21.2±10.9%). No other variables were significantly different. **Conclusions:** Although previous research suggests that unstable ankles have diminished force sense, those findings were not supported in this study. Our results suggest that both copers and individuals with unstable ankles have an improved ability to match ankle loads when compared to healthy ankles, as measured through variable error. The ankle copers were the most consistent at matching accurate force repro-duction. No previous studies have investigated force sense in a group of copers. This data suggests that the heightened perception from intact musculo-tendinous receptors and/or the neuromuscular control of joint loading may be compensatory adaptation/s after trauma to capsuloligamentous tissue and denervation of the receptors within static stabilizers.

Reactive Joint Stiffness is Impaired in Functionally Unstable Ankles

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Context: While many individuals with ankle sprains complain of sudden "roll-over" events, no data exists quantifying the reactive stiffening properties that could resist these injurious forces during unanticipated loading. Optimal stiffness regulation may be dependent on different static and dynamic restraint characteristics to stabilize the joint while the ankle undergoes forced supination range of motion. Moreover, there are certain individuals who can cope with an ankle sprain and avoid functional instability; yet limited data is available on these patients. **Objective:** To determine the effect of varying degrees of

functional stability on stiffening regulation strategies at the ankle joint. **Design:** Post-test only with comparison groups. **Setting:** University laboratory. **Subjects:** Eighty-one subjects (22.3±3.1yrs; 171.2 ±9.7cm; 71.8± 17.4kg) provided 96 ankles for this study. Ankles were stratified into 3 groups using the Cumberland Ankle Instability Tool (CAIT): controls (CON, n=69), copers (COP, n=29), mildly functionally unstable (SPR, n=27), and functionally unstable ankles (UNS, n=28). **Interventions:** Subjects were position-ed in a custom built stiffness device that generated a rapid 20° supination perturbation to the ankle joint. Subjects exerted a pronation force at 30% of their maximum, and then reacted with maximal resistance as quickly as possible when a supination perturbation was sensed. **Main Outcome Measures:** Normalized ankle joint stiffness (Δtorque/Δrotation, Nm/°/kg) was calculated at the short range (0-3°), mid-range (0-10°), peak (0°-Peak Torque) and total (0-20°). A 2-way repeated-measures analysis of variance was used to compare differences between groups and stiffness ranges. **Results:** A significant group by range interaction was observed (F=2.40, p=0.01). Across all groups, short-range stiffness (0.099±0.04in-lb/°/kg) was significantly higher than mid-range (0.051±0.02in-lb/°/kg), total (0.043± 0.02in-lb/°/kg), and peak stiffness (0.047±0.02in-lb/°/kg, p<.001). Pairwise comparisons revealed CON had significantly greater short-range and mid-range stiffness than UNS (p=0.046, p=0.023) and SPR (p= 0.032, p=0.048). Additionally, COP had significantly lower peak stiffness than CON (p=0.047) and UNS (p=0.032). **Conclusions:** Our data suggests that mildly and highly unstable ankles have diminished reactive stiffening properties when compared to healthy ankles. These differences could be representative of alterations to both static and dynamic restraint mechanisms. Lower short-range stiffness has been associated with parallel and series elastic components of the muscle, while lower mid-range stiffness would result from the regulation of cross-bridge cycling during eccentric lengthening. Additionally, copers were observed to have less peak stiffness than healthy and unstable ankles, indicating a degree of compliance that may aid in the absorption of energy throughout the perturbation range. This data indicates a need to examine the neuromechanical relationship between innate properties of the joint and the central nervous system.

Relationships between Measures of Posterior Talar Glide and Ankle Dorsiflexion Range of Motion in Patients with Acute Ankle Sprains

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Context: Limitations in dorsiflexion range of motion (ROM) are common following lateral ankle sprain. It has been hypothesized that limitations in dorsiflexion ROM are associated with restrictions in posterior talar glide, however little is known about the relationships between the two. **Objective:** To examine the relationships between four different dorsiflexion ROM measurements and posterior talar glide in patients with subacute lateral ankle sprain. **Design:** Descriptive laboratory study. **Setting:** Laboratory. **Patients or Other Participants:** Thirty-four patients (19 male, 15 female, age=22.4±4.2years, height =174.4± 10.7cm, mass=75.7±11.7kg) with grade I or II subacute ankle sprains participated. **Interventions:** Measurements were taken on both the injured and uninjured limbs of subjects an average of 4.3±2.6 days after ankle sprain. **Main Outcome Measures:** Four different dorsiflexion ROM measurements were taken (seated straight knee (SSK), prone bent knee (PBK), standing straight knee (STSK) and standing bent knee (STBK)). Posterior talar glide was assessed manually using the posterior talar glide test (PTGT) and posterior talar displacement was assessed with an ankle arthrometer. For each dependent variable, the average of the three measurements was used for analysis. Within each limb, Pearson's product moment coefficients were used to examine relationships between measures of dorsiflexion ROM and posterior talar glide and displacement measures. **Results:** Means and standard deviations on the injured and uninjured limbs, respectively, were: SSK (3.5º±7.2º, 14.2º±6.1º), PBK (2.9º± 6.8º, 14.9 º±6.4º), STSK (22.4º±7.4º, 34.8º±6.1º), STBK (23.4º±7.4º, 37.3º ±7.2º), PTGT (11.6º±4.2º, 17.1º± 6.0º), and displacement (5.4º±3.0mm, 5.1º±3.0mm). In the injured limbs, there was a weak but significant positive correlation between talar glide as assessed with the PTGT and dorsiflexion ROM in the SSK and STSK positions (r=.36, p=.04; r=.38, p=.03, respectively) and moderate positive correlation between the PTGT and the STBK position (r=.45, p=.008). We also observed a moderate positive correlation between posterior talar displacement as assessed with the ankle arthrometer and dorsiflexion ROM (PBK r=.54, p=0.007; STBK r=.42, p=0.045) on the injured limb. In the uninjured limbs, moderate positive correlations were established between PTGT and dorsiflexion ROM in the SSK, PBK and STSK positions (r=.45, p=.008; r= .47, p=.007, r=.40, p=.02, respectively). No significant correlations were identified between posterior talar displacement as assessed with the ankle arthrometer and dorsiflexion ROM in the uninjured limbs (p>.05). **Conclusions:** Restrictions in posterior talar glide when assessed manually (PTGT) and with an instrumented device (ankle arthrometer) were positively correlated with limitations in dorsiflexion ROM in the injured and uninjured limbs of patients with subacute ankle sprains. These results provide evidence of a direct relationship between arthrokinematic and osteokinematic restrictions in patients recovering from ankle sprains. Clinical evaluation that includes an assessment of non-contractile components following an ankle sprain may help guide treatment and rehabilitation decisions.

The Effectiveness of Neuromuscular Training on Modifiable Anterior Cruciate Ligament Injury Risk Factors

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Context: Approximately 80% of ACL injuries are linked to noncontact mechanisms, and more than 70% occur when landing from a jump. Females have more risk factors and sustain 4-6 times more ACL injuries than males. Neuromuscular training (NMT) programs have been shown to reduce the rate of female ACL injuries by modifying risk factors. However, a major problem with this research is it lacks adequate control groups, making it difficult to determine whether these benefits are due to the NMT program or an increase in exercise workload. **Objective:** To evaluate the effectiveness of a NMT program on a modifiable ACL risk factor relative to a resistance training (RT) program of equal volume and frequency of exercise in females. **Design:** Single-blinded randomized clinical trial (Identifier: NCT01433718). **Setting:** Laboratory testing; training sessions were performed in a fitness facility. **Patients or Other Participants:** Female college underclassmen (N=29; Age=18.8±0.7 years; Height= 116.1 ±7.4 cm; Weight=61.7±8.9 kg) volunteered for this study. Participants were assigned to the NMT or RT group by covariate adaptive randomization for Body Mass Index and athletic experience. **Interventions:** Participants performed either NMT or RT consisting of 3 training sessions per week for 6-weeks of equivalent exercise volume and frequency after baseline testing (NMT: n=15; RT: n=14). **Main Outcome Measures:** Landing mechanics were analyzed using Sportmetrics drop jump test (DJT) software to measure knee separation relative to hip width at Pre-Land, Landing, and Take-Off. The tests were repeated after the completion of training. Three 2x2 repeated measures ANOVA with an intent to treat approach were calculated for knee separation at Pre-Land, Landing, and Take-Off (alpha<0.05) **Results:** There was no significant interaction for Pre-Land knee separation ($F_{1,27}$ = 0.05; P>0.05). NMT baseline group mean knee separation was 61.1 ± 0.2% and RT was 53.9 ± 0.1%. After training, NMT knee separation was 58.5 ± 0.1% and RT knee separation was 50.9 ± 0.1%. There was no significant interaction ($F_{1,27}$ = 0.43; P>0.05) for Landing knee separation. NMT baseline mean knee separation at Landing was 49.6 ± 0.2% and RT was 41.4 ± 0.1%. After training, NMT knee separation was 45.0 ± 0.2% and RT separation was 39.1 ± 0.2%. There was no significant interaction for Take-Off knee separation ($F_{1,27}$ = 0.42; P>0.05). Prior to training, the NMT group's mean knee separation at Take-off was 47.7 ± 0.2% and RT was 39.0 ± 0.1%; following training NMT mean knee separation was 45.5 ± 0.2% and RT was 38.9 ± 0.1%. **Conclusions:** Our results suggest that there was no additional benefit from NMT in knee separation index during the DJT relative to a comparable control. Additional research is needed to determine if the reduction of ACL injuries is still present when compared to adequate controls. Funded by the NATA Foundation Masters Grant Program.

Improved Dynamic Balance Following a Lower Extremity Neuromuscular Control Program in Division I Women's Basketball Players

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Context: Deficits in dynamic balance, specifically, in the anterior reach direction of the Star Excursion Balance Test (SEBT), have been used to predict acute lower extremity injury. Interventions targeting neuromuscular control have demonstrated improved dynamic balance as measured by the SEBT. However, the duration in which improved dynamic balance can be sustained following completion of an intervention remains unknown. **Objective:** To determine whether dynamic balance can be improved and maintained over the duration of a competitive basketball season following a 6-week neuromuscular control intervention. **Design:** Controlled Laboratory Study. **Setting:** Research Laboratory. **Patients or Other Participants:** Eleven Division I female basketball players (19.40 ±1.35 yrs; 178.05±7.52 cm, 72.86±10.70 kg) volunteered. **Intervention(s):** Participants were tested at three separate sessions: baseline; immediately following the 6-week training session (POST1) and 9 months following baseline (POST2). During each session, participants performed three trials of the anterior, posteriormedial and posteriorlateral reaches of the SEBT using each limb. The order of testing for limb and SEBT directions was randomized. The neuromuscular control and plyometric training program consisted of 18 sessions over a 6-week period, supervised and progressed by 2 Certified Athletic Trainers. The exercises focused on improving lower

extremity neuromuscular control and emphasized proper landing techniques. **Main Outcome Measures:** The average of the 3 test trials for each leg was reported as a percentage of leg length. An average of the normalized scores for both limbs in all three directions (anterior, posteriormedial, posterior-lateral) was used for analysis. A composite score was created by averaging the normalized values from the three measured reach directions to create a single normalized value. Imputed means were calculated for two participants at one time point (one for POST1 and one for POST2) who were unable to participate due to injury. Four separate 1x3 repeated measures analysis of variance tests were performed to identify differences over time in the 4 normalized reach values (anterior, posteriormedial, posterior-lateral, composite). Post-hoc dependent t-tests were performed to determine if posttests differed from pretest values. A priori significance level was set at $P \leq 0.05$. **Results:** The mean for anterior and composite reach were significantly different over time ($F_{2,10}=5.16$, P= 0.016; $F_{2,10}=6.96$, P= 0.005 respectively). Baseline anterior reach (63.37$\pm$3.18%) was significantly lower than POST1 (65.36$\pm$2.88%; $t_{10}=-2.71$, P= 0.022) and POST2 (66.21$\pm$5.27%; $t_{10}=-2.69$, P=.023). Similarly, baseline composite reach (70.41$\pm$4.08%) was lower than POST1 (73.38$\pm$419%; $t_{10}=-3.75$, P= 0.011) and POST2 (74.2$\pm$4.77%; $t_{10}=-3.78$, P=.004). **Conclusions:** Dynamic balance can be improved and sustained through a competitive athletic season following a 6-week neuromuscular control intervention. Lower extremity neuromuscular control training produces long term benefits in improved dynamic balance. Future research will need to determine if improvement in dynamic stability will be beneficial for injury risk reduction.

The Effects of Dynamic Warm-Up, and the Combination of Dynamic and Static Warm-Up on Sprint Performance Times in Collegiate Power Athletes

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Context: Better ways for athletes to warm-up and prepare for events could directly affect performance and injury prevention. Athletic trainers with knowledge and understanding of warm-up procedures could influence injury prevention. **Objective:** To determine the effects of dynamic warm-up and the combination of static stretching and dynamic warm up on sprint performance times in collegiate power athletes. **Design:** Randomized Cross-over Clinical Trial **Setting:** Controlled environment on a 200 m indoor track. **Patients or other participants:** 24 healthy, NCAA II collegiate baseball, softball and track and field athletes (12M, 12F, Age=19.46±1.38yr, HT= 1.72± .11M, WT=69.46± 13.61 kg). I**ntervention:** Subjects reported for three testing sessions, performing one of three 25 minute warm-up protocols (dynamic warm-up, combination warm-up, and control) during each testing session. The order of protocols was counterbalanced to decrease any cumulative effect. Subjects completed a 5 minute jog at a self-determined pace as a general warm-up. The dynamic warm-up included 2 x 20 m bouts of straight leg skips, walking high knees, running high knees, and flick backs with 10 s rest between sets, finishing with 2 x 50 m striders. The combination warm-up included 3 x 30 sec stretches alternating legs, including standing gastrocnemius, lying straight leg raise, standing quad, gluteus, and static lunges, followed by the dynamic warm-up protocol. Control subjects completed the 5 minute jog, sat for 15 minutes then completed the striders. Statistical analysis included a repeated measures 1x3 ANOVA with pairwise comparison comparing subjects to their own times from each protocol. The significance level was set at ≤ 0.05. IRB approval was obtained prior to data collection. **Main Outcome Measure:** Two 60m maximum effort standing start sprints, recorded by two researchers using a standard stopwatch (Accusplit Pro Survivor 601X 3V). A stop watch has been determined to be valid and reliable. The average time for the fastest trial was calculated from both researchers and used for analysis. Inter-tester reliability of trials was excellent with ICC(3,k)=0.983 over all trials and days. **Results:** Descriptive statistics were as follows: Dynamic warm up 8.61± 0.5 s, Combination warm up 8.65±0.49 s, Control 8.77± 0.49 s. There was a significant difference between conditions $F(2,46)= 5.41, \alpha = 0.048$. Using a pairwise comparison, the dynamic warm-up was .04 s faster than the combination warm up which was not significantly different (p=.364). The dynamic condition was .16 s faster than the control (p=.009). The combination warm-up was .12 s faster when compared to the control (p=0.03) **Conclusions:** The two best warm up options to optimize performance are dynamic or combination warm up. During dynamic warm up, subjects were exposed to movement patterns used during sprints; their bodies may adapt quicker leading to decreased sprint time. The combination warm-up is good for athletes preferring a static stretch.

The Influence of Athletic Participation on the Degree of Change of Scapular Upward Rotation

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Context: Athletic participation characteristics, such as the sport and position played, have been found to affect static scapular upward rotation. However, previous studies have used

the static scapular upward rotation measurements taken at specific positions of humeral elevation to make the comparisons. It is unclear if the degree at which scapular upward rotation changes from position to position is different between groups with various athletic participation characteristics. **Objective:** To assess the position interval degree of change of scapular upward rotation between healthy male overhead athletes, non-overhead athletes and non-athletes. **Design:** One-between (group), one-within (position interval) mixed model. **Setting:** Controlled laboratory environment. **Patients or Other Participants:** Thirty-nine males with no history of shoulder injury participated in this study: 13 intercollegiate overhead athletes (19.8±1.4 y, 181.8±6.6 cm, 88.4±8.4 kg), 13 intercollegiate non-overhead athletes (20.8±1.3 y, 178.9±5.9 cm, 83.4±15.6 kg) and 13 recreationally fit non-athletes (21.8±0.8 y, 178.9±6.8 cm, 89.1±11.4 kg). **Interventions:** Static scapular upward rotation was measured on the throwing dominant arm with a digital protractor while subjects were at rest and at 60°, 90° and 120° 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 upward rotation measurements at each position were averaged. For each subject, the average upward rotation measurement at each position was subtracted from the average upward rotation measurement at the subsequent position to yield a degree of change at three position intervals: 60°-rest=interval 1, 90°-60°=interval 2 and 120°-90° =interval 3. The independent variables were group (overhead, non-overhead and non-athlete) and position interval (interval 1, interval 2 and interval 3). **Main Outcome Measures:** The dependent variables were the degrees of change of scapular upward rotation at the three position intervals. A one-between, one-within repeated measures ANOVA was performed. Level of significance was $p<.05$. **Results:** The statistical analysis revealed a significant main effect within the position intervals ($F_{2,72}=70.564$; $p<0.001$). Pairwise comparisons determined interval 3 (17.4±4.9°) was significantly greater than interval 2 (15.3±4.3°) and interval 1 (5.6±4.9°), while interval 2 was significantly greater than interval 1. There was no main effect for group ($F_{2,36}=2.253$; $p<0.120$) and there was no group X position interval interaction ($F_{4,72}=2.042$; $p<0.098$). **Conclusions:** Differences in the degree of change of scapular upward rotation within the three position intervals were evident. Previous research determined differences in static scapular upward rotation between groups with various athletic participation characteristics. However, the current study found the position interval degree of change of scapular upward rotation between healthy overhead athletes, non-overhead athletes and non-athletes to be similar. Future research should investigate the degree of change of scapular upward rotation in an injured population to determine if a similar outcome exists.

The Effect of Surface Angle on a Six-Week Single Leg Squat Exercise Program.

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Context: Single leg squat (SLS) is utilized in rehabilitation of lower extremity injuries. A SLS performed on a declined angled surface (DSS) increases quadriceps activity and is recommended for treating patellar tendinopathy. Little is known regarding the efficacy of SLS or DSS in regard to strength or functional performance. **Objective:** To evaluate the effect of surface angle during SLS on quadriceps strength and functional performance. **Design:** Randomized control trial. **Setting:** Research laboratory. **Patients or Other Participants:** Twenty-six healthy, physically-active, volunteers were stratified according to injury history and physical-activity level, and then randomly assigned to the level surface SLS (LSS, n=10; 20.89± 1.76yrs, 168.3±8.4cm, 68.68± 9.85kg), decline surface SLS (DSS, n=10; 20.89±2.84yrs, 171.94±8.7cm, 70.18 ±13.38kg) or control (CON, n=6; 20.83±2.92yrs, 166.33 ± 5.98 cm, 66.43±8.84kg). Two participants were excluded after missing >25% of exercise sessions. **Interventions:** Pretest-posttest measures of strength and functional performance included a modified Star Excursion Balance Test in anterior (YANT), posteriolateral (YPL), and posteriomedial (YPM) directions, Step-Up-and-Over-Test (SUO, NeuroCom, Inc), single leg hop (SLH), single leg triple hop (SL3H) and peak torque at 60 degrees/second (Biodex, Inc). Participants completed practice trials of all tests to familiarize themselves with the exercises and equipment. Participants assigned to LSS or DSS (15° angle) performed 3x15 repetitions, twice/day, 3 days/ week for 6 weeks, with bodyweight resistance only. Exercise sessions were supervised. All participants were encouraged to maintain normal physical activity for the duration of this study. **Main Outcome Measures:** The dependent variables were the change scores for normalized YANT, YPL, and YPM, SUO Lift-up and Impact Indices (LI and II, respectively), SLH, SL3H, and peak torque at 60 degrees/second. ANOVA was utilized to compare the groups with a Bonferroni post-hoc analysis. Alpha was set at .05. **Results:** We found no significant differences between groups in regard to changes in functional performance measures. All groups had negligible decreases in LI and II (LSS -2.0±9.8; DSS -0.66±7.66; CON -1.83±9.43; p= .945; LSS -1.44±7.6; DSS -2.66±9.19; CON -6.5±5.2; p=.468, respectively). Changes in SLH and SL3H were not statistically significant (SLH: LSS 5.45±7.47; DSS 5.44±10.21; CON 15.18±12.59, p=.140; SL3H: LSS 13.46±18.82; DSS 14.67±16.98; CON 27.58±24.70, p=.364). No significant differences were identified between groups for YANT (LSS -1.82±4.12; DSS 7.66±15.26; CON

4.29±9.83, p=.198), YPL (LSS 19.5±10.45; DSS 11.14±7.57; CON 14.82±7.17, p=.516) or YPM (LSS 12.64±13.5; DSS 9.99±17.27; CON 15.39±7.14, p=.765). The only significant difference between groups was the change in peak torque at 60 degree/second with the control group demonstrating greater change than either of the treatment groups (LSS -2.044±15.11, DSS -7.48±9.95, CON 12.433±2.78, p= 0.24). **Conclusions:** A six week training program of bodyweight exercise was not sufficient to improve strength or functional performance measures included in this study. Further research with overload training is recommended.

Hip and Knee Joint Kinematics During Lateral- and Front-Single Leg Stepdowns

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Context: Single-leg stepdowns are commonly used in rehabilitation of various injuries involving the lower extremity, and can be performed to the front (FSD) or laterally (LSD). Research has shown that the implementation of FSD within a rehabilitation protocol is effective in decreasing the symptoms of patello-femoral pain and improving proximal strength; however, there is no research identifying the biomechanical differences between the FSD and the LSD. **Objective:** To compare 3D kinematics during performance of the FSD and LSD. **Design:** Repeated measures. **Setting:** Neuromechanics Laboratory. **Subjects:** Ten healthy participants (7 females, 3 males; age 21.3±2.2 years, height=171.9±4.6 cm, mass=69.4±4.7 kg) with no history of lower extremity pathology of the dominant limb or balance disorders volunteered. **Interventions:** The independent variable was the direction of squat performed (LSD, FSD). After completing several practice trials, participants performed three sets of five repetitions of each squat from a 6-inch box. The timing of the descent and ascent of each squat was maintained by a metronome set at 60bps. The middle three repetitions of each set were analyzed. **Main Outcome Measures**: The dependent variables were joint angles at peak knee flexion for the hip and knee in the sagittal, frontal, and transverse planes. Dependent t-tests were used for analysis. The alpha level was set at $p<0.05$. **Results:** Significant differences between FSD and LSD were found. At the knee, significantly greater flexion (FSD: 73.9±5.9°, LSD: 68.4±4.3°, p=0.002), adduction (FSD: 9.22±2.8°, LSD: 6.02±4.3°, p=0.003), and external rotation (FSD: 5.49±6.9°, LSD: 7.61±6.4°, p=0.008) was produced during the FSD than LSD. At the hip, the FSD resulted in greater hip adduction (FSD: 13.7±6.9°, LSD: 11.6±6.5°, p=0.012) but not different in hip flexion (FSD: 37.8±11.3°, LSD: 38.9±12.2°, p=0.491) or internal rotation (FSD: 3.95±4.5°, LSD: 5.15±6.2°, p=0.288). **Conclusions:** The FSD task resulted in greater knee and hip angles when compared to the LSD completed from the same height. The FSD is a more demanding task and requires greater control of the limb, specifically in the frontal plane. Clinicians would be advised to use an FSD when attempting to screen for poor proximal control of the femur and possibly injuries like patellofemoral pain or illiotibial band syndrome. Clinicians may also wish to progress patients through rehabilitation starting with the LSD and moving to the FSD.

The Feasibility of Implementing an Injury Prevention Program in High School Basketball Players

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Context: In rural and low-income areas, access to health care is limited and injury prevention programs are not readily available. Balance training has been shown to reduce ankle and knee injuries under the supervision of a healthcare professional, however, little is known about what can be done to prevent injuries in these underserved locations. **Objective**: To determine the feasibility of implementing an injury prevention program for boys and girls basketball teams at rural, underserved Kentucky high schools. **Design**: Cohort study. **Setting**: Field-testing. **Patients or Other Participants**: Four rural inter-scholastic high school basketball teams in Kentucky that included 2 boy's teams (Team A n=19, Team B n=11), 2 girls teams (Team C n=18, Team D n=9) and 4 coaches 2 males (Teams A, B) and 2 females (Teams C and D). **Interventions**: Each coach was given an injury prevention program that utilized evidence-based exercises. Coaches were provided with exercise descriptions and a video demonstrating each exercise. An athletic trainer instructed coaches on proper technique and commonly made errors. Coaches were instructed to implement the exercise program three times per week throughout the course of the season. A log of practice, games, and exercise sessions was documented by the coaches and submitted once a week. Single-limb postural control was assessed pre- and post-intervention using measures of Time-to-Boundary (TTB). Each subject was tested bilaterally for 3 trials of 10s and the mean was taken for each limb. **Main Outcome Measures**: The dependent variables were the compliance rate to complete the exercise program three times per week, percentage of subjects that drop-out and TTB measures. Compliance was calculated by number of sessions completed divided by number of sessions proposed. Acceptable compliance was set at 90% a priori. T-tests were used to measure the differences in TTB pre to post for each team. **Results**: Overall, the compliance rate was 65%± 0.10. Team C met adequate compliance levels at 96%± 0.10, while Teams A, B, and D resulted in unacceptable compliance rates 53%± 0.20, 49%± 0.30, and 88%± 0.20 respectively. Drop-out rate was less than 1%. An increase in the anterior/posterior TTB standard

deviation of the minima of the right leg (2.88 ± 0.41, p= 0.05) and a trend in increased postural control for the absolute minimum in the anterior/ posterior direction of the right leg (1.47± 0.22 p= 0.09) for Team C were present. However, TTB measures did not change significantly for Teams A, B, or D. **Conclusions**: The inconsistency among the four teams indicates that this program is feasible and able to increase postural control for certain coaches, but not overall. Factors such as gym schedule, school cancellations, and other unforeseen circumstances might have played a role to reduce compliance and effectiveness of the program.

Visual Distraction Does Not Alter Static or Dynamic Upright Postural Stability in Healthy Subjects

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Context: An individual's ability to maintain upright standing balance involves the integration of visual, vestibular, and somatosensory information.Visual stimuli must be accurately perceived and processed for an individual to maintain normal postural stability during alterations of the visual environment. There is little research documenting the impact of visual distraction (i.e. optical flow motion) on static or dynamic standing balance among healthy subjects. Symptoms that affect the visual system following a concussion may influence an athlete's ability to decipher which information is important and true and which information is incorrect. **Objective:** To identify the influence of visual distraction on standing balance and postural stability in normal, healthy subjects during static and dynamic balance tasks. **Design:** A ran-domized,crossover study design was used. **Setting:** University research laboratory. **Patients or Other Participants:** Twenty-one healthy subjects (age 22.10 ±1.61; 9males, 12females) with no history of lower extremity injury or surgery within the last 6 months, no prior head injury, no neurological condition or balance problems. **Interventions:** All subjects com-pleted the Sensory Organization Test (SOT), Adaptation Test (ADT), and the Modified Clinical Test of Sensory Interaction on Balance (mCTSIB) onthe NeuroCom® Smart Balance System. Each subject's standing balance was tested under two visual testing conditions: (1) standard testing methods without specific instructions given to the subject to focus the visual field at a specific location, and (2) visual distraction through optical flow motion. A computer-generated optical flow pattern was used as the visual distraction stimulus. Testing procedures were counter-balanced for order of the testing (standard protocol or visual distraction) and for the order of each balance test (SOT, ADT, mCTSIB).**Main Outcome Measures:** Composite equilibrium score (weighted average of all the scores), sensory systems preference (degree to which subject relies on visual, vestibular, or somatosensory information) from the SOT; magnitude of response for the ADT; and mean center of gravity sway velocity for the mCTSIB. **Results:** The presence of visual distraction had no significant effect on upright postural stability asmeasured by the SOT composite equilibrium scores (t_{20}=1.228,p=0.234, 95% confidence interval [CI],-0.90-3.47), SOT sensory analysis [somato-sensory (t_{20}=0.997, p=0.331, 95% CI,-0.01-0.02), visual (t_{20}= 0.852 p=0.404, 95% CI,-0.04-0.08), vestibular (t_{20}=0.930, p=0.364, 95% CI,-0.22-0.06), sensory system preference (t_{20}=0.726, p=.476, 95% CI,-0.32-0.07)],ADTmagnitude of response (toes up t_{20}=-0.710, p=0.486,, 95% CI,-7.87-3.87; toes down t_{20}=0.403, p=0.691,95% CI.-2.66-3.94) and mCTSIB mean center of gravity sway velocity (t_{20}=-0.418, p= 0.680, 95% CI, -0.06-0.04). **Conclusions:** Visual distraction had no significant effect on standing balance and postural stability in the presence of altered optical flow**.** Healthy subjects were able to disregard visual distraction and maintain upright balance. The influence of visual distraction on static and dynamic standing balance among individuals with concussion is unknown and warrants investigation.

Improvements in Muscular Endurance Following a Baseball Specific Strengthening Program in High School Baseball Players

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Context: Preventative strengthening programs for adolescent baseball players have been suggested, but little empirical data exist regarding their effectiveness for this population. **Objective:** To determine changes in upper extremity muscular endurance in adolescent baseball players during an 8 week pre-season training regimen with follow up at 20 weeks, which represented the start of the spring baseball season. Secondarily, changes in strength, range of motion and in-season time lost to injury were examined. **Design:** Pre-test post-test. **Setting:** Sports medicine clinic. **Participants:** 14 baseball players (age=16±2yr; ht=182±8cm; mass= 75±11kg; 11 pitchers/catchers) with no recent injury were tested at 4, 8 and 20 weeks. **Interventions:** Participants attended three supervised training sessions/week. Strengthening of the scapular, rotator cuff and forearm muscles was performed using a stair-step progression emphasizing repetition over load. Additional conditioning for the lower extremity (LE) was imple-mented for major muscle groups using body weight and elastic resistance. **Main Outcome Measures:** Internal rotation (IR) and external rotation (ER) strength and motion were assessed at 90° abduction. Posterior shoulder endurance test (PSET), measured in Nm, required the participant to perform repetitions to failure of prone horizontal abduction to 90° using 2% of their body. PSET reliability was performed a priori (ICC=.81, SEM=13.7Nm). Maximum distance hopped on a single leg was used to evaluate LE strength. Separate mixed

model linear analyses were performed for each variable, followed by a Bonferroni post-hoc analysis as appropriate ($\alpha \leq .05$). **Results**: Posterior shoulder endurance improved ($p<.001$), increasing from 437±209Nm at baseline to 941±472Nm at 4 weeks ($p=.001$) and remained elevated throughout the program. Single leg hop work improved bilaterally ($p<.001$), increasing from 1006±278Nm to 1505±354Nm in the lead leg and from 959±271Nm to 1451±362Nm in the stance leg at 4 weeks ($p<.001$) and remained elevated throughout the program. IR ROM, total arc of motion (ER+IR) and ER/IR strength ratio did not change over the course of the program ($p>.05$). For the 13 participants who played spring baseball, the total player-games for the 10 week season equaled 270 exposures. Three participants sustained injury during the season (sprained ankle, back muscle strain, hamstring strain), for a total of 7 games missed due to injury. No shoulder or elbow injuries were reported. **Conclusions**: While muscular endurance increased, strength did not, which reflects the specificity of training of this program toward endurance and is likely due to the pre-existing high strength ratio in this cohort. These findings indicate clinicians should address both strength and endurance as separate constructs. Assessment and training of endurance is of particular importance given the documented link between arm fatigue and shoulder pain in throwers. This study describes a simple clinical measurement of shoulder endurance. Finally, this evidence suggests that participants in the pre-season training program were adequately prepared for the season and incurred minimal time loss due to injury.

The Effect of Different Cold and Compression Treatment Protocols on Femoral Artery Blood Flow and Tissue Temperature in Healthy Subjects

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Context: Cryotherapy and compression are recommended for the control of hemorrhage and inflammation. However, limited information exists comparing tissue temperature decreases and global blood flow changes using various treatment protocols. **Objective**: To examine the effects of two Game Ready® treatments with cyclical cooling/pneumatic compression (on) and passive recovery (off) [30 on/30 off/30 on/30 off (GR1) and 30 on/90 off (GR2)] on intramuscular temperature (T_{IM}), skin surface temperature (T_{SK}), mean arterial blood pressure (MAP), and femoral artery blood flow (FBF). **Design**: Within repeated measure designs. **Setting**: Controlled laboratory setting. **Participants**: Seven males (age= 22±2 yr, mass=88±11 kg, height= 183±6 cm, thigh skinfold=16.6±7.1 mm) volunteered. All had no current injury involving their lower extremity and were not taking prescription medications. **Interventions**: Game Ready® with ice water and knee/thigh sleeve with medium pneumatic compression (5-50 mmHg) was used. Knee sleeve was left in place during passive recovery. GR1 was delivered using a manufacturer preset for two successive cycles and GR2 was delivered using 30 on/90 off. A thermocouple inserted 1.5cm below the subcutaneous adipose layer sampled T_{IM} and a surface thermocouple sampled T_{SK}. Thermocouples were interfaced to a computer through an Isothermex®. Heart rate and blood pressure were collected using a 3-lead ECG and automated blood pressure device. A hand-held probe was placed on the skin over the common femoral artery where Doppler ultrasound measures of femoral blood velocity and femoral diameter were used to calculate FBF. Measurements were taken at predetermined time points from both the cryotherapy treated leg and the non-treated leg. **Main Outcome Measures**: T_{IM} and T_{SK} (°C), MAP (mmHg), and change from baseline for FBF (ml/min) (Mean±SE). Separate 2-way repeated measure ANOVAs with levels including treatment (GR1/GR2), leg (treated and non-treated), and/or time (0, 15, 30, 45, 60, 75, 90, 105,120 minutes) were used. T_{IM}, T_{SK}, and MAP were analyzed with 2 x 9 (treatment x time), FBF was analyzed using a 2 x 9 (leg x time) and with a 2 x 9 (treatment x time) for treated leg. Alpha set a priori at 0.05. **Results:** For GR1, T_{IM} was colder for 45-120 minutes compared to GR2 ($p<0.05$). Maximum T_{IM} change from baseline (GR1: -9.9±1.2 vs GR2:-5.8±0.98°C) occurred at 90 minutes. For MAP, there were no significant treatment or time differences ($p>0.05$). The average change for FBF for the treated leg was not significantly different ($p=0.52$) between GR1 (-121±15.4 ml/min)andGR2 (-159± 23.2 ml/min), but for both treatments the cooled leg exhibited greater reductions in blood flow when compared to the control leg ($p=0.02$). **Conclusions**: Cycled cold water and compression produced significant decreases in both femoral blood flow and tissue temperature. However, more research is warranted to clarify the time course and magnitude of these changes in injured tissue.

Time for a Paradigm Shift? The Role of Cryotherapy on Microvascular Perfusion

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Context: A main rationale for using cryotherapy after acute injury is to decrease blood flow in the cooled area as decreased blood flow may attenuate inflammation and hasten recovery from injury. It is unknown whether cryo-therapy results in decreased blood flow in skeletal muscle with delayed onset muscle soreness (DOMS). **Objective:** To examine the effect of repeated cryotherapy interventions on microvascular perfusion and pain in the 48 hours after eccentric exercise to the gastrocnemius utilizing a DOMS model. **Design:** Randomized controlled laboratory study. **Setting:** Laboratory. **Patients or Other Participants:** Eighteen healthy participants volunteered (3M, 15F; Age: 22.2±2.2 years; Height: 166.0±11.9 cm; Weight: 69.4±25.0 kg). **Intervention(s):** Subjects performed 100 heel-lowering exercises off a step in a sequence of 50 repetitions, 5-minutes rest, 50 repetitions to the beat of a metronome. Subjects were randomized to one of three intervention groups (cryotherapy, sham, control). A 750g ice bag was used for cryotherapy, a 750g bag of candy corn was used for the sham, and a towel was used for the control. Treatments were applied to the exercised leg after the microvascular perfusion measurement immediately following exercise and 10, 24, and 34 hours after exercise. **Main Outcome Measures:** Perfusion measurements (blood volume (dB), blood flow (dB/sec), and blood flow velocity (sec^{-1})) were taken using contrast-enhanced ultrasound at baseline, immediately

after exercise (within 5 min), immediately after initial treatment, and 48 hours after exercise. Microvascular perfusion was measured at a 1cm depth into the medial gastrocnemius. Visual analog scale (VAS) scores (mm) for pain were taken at baseline, 10, 24, 34, and 48 hours after exercise. Separate intervention by time repeated measures ANOVAs were calculated for each dependent variable. **Results:** There were no significant interactions for the microvascular perfusion measures, however, significant time main effects for blood volume and blood flow ($p<.001$) were found. Baseline volume (5.9±1.3 dB) and flow (2.3±0.4 dB/sec) measurements were significantly less than measurements immediately post-exercise (12.2±3.3 dB, 4.52±1.05 dB/sec), post-intervention (11.5±3.3 dB, 4.1±0.9 dB/sec) and at 48 hours (11.8±3.1 dB, 4.4±1.0 dB/sec). There was a signi-ficant intervention by time interaction for VAS scores ($p=.009$). Pain was significantly less at 34 hours (22.3 ±12.8 mm) and 48 hours (29.8±117 mm) for the cryotherapy group compared to control (38.3±14.6 mm and 52.5±15.1 mm, respectively). Cryotherapy VAS scores were also less at 34 hours compared to sham (45.50±14.16 mm). **Conclusions:** With DOMS in the gastrocnemius, four applications of cryotherapy did not affect microvascular perfusion over 48 hours however, cryotherapy did decrease pain. These results challenge the longstanding hypothesis that ice decreases intramuscular blood flow to cooled areas. A paradigm shift may be needed as the clinical benefits of cryotherapy after muscle injury may be primarily due to sensory effects.

Effect of Cryotherapy on Delayed-Onset Muscle Soreness

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Context: After acute injury, cryotherapy is typically the first line of defense against pain, swelling, and functional deficits. Cryotherapy is believed to attenuate the inflammatory process and speed recovery time. Most research has focused on a single application of ice or cold-water immersion.However, clinically, several cryotherapy applications are applied over consecutive days to minimize the effects of injury. **Objective:**To determine whether two cryotherapy interventions a day for two days would improve the signs and symptoms of delayed-onset muscle soreness (DOMS) in the gastrocnemius over 96 hours. **Design**: Descriptive laboratory study. **Setting**: Laboratory. **Patients or Other Participants**: Thirty-six healthy subjects volunteered to participate (8 M, 28 F; Age: 23.4 ± 3.2 years; Height: 168.0 ± 11.9cm; Weight: 68.3 ± 15.4 kg). **Inter-vention(s)**: Subjects performed unilateral eccentric exercises on a randomly selected leg. Calf-lowering repetitions were performed from a raised exercise step to the beat of a metronome. The eccentric portion of the exercise lasted 3 seconds. The sequence was 50 repetitions, 5 minutes rest, and 50 repetitions. Immediately after the exercise, either a 750g-crushed ice bag or towel (control intervention) was randomly applied to the gastrocnemius in a prone positionfor a pre-determined amount of time based on skinfold thickness. The intervention was againapplied 10, 24, and 34hours after the initial exercise. **Main Outcome Measures**: Calf girth (cm), dorsiflexion range of motion (°), plantarflexion strength (kg), pain on a visual analogue scale (mm), point tenderness (kg/cm^2), and self-reported function using the Lower Extremity Function Scale (%)were all measured at baseline, 10, 24, 34, 48, 72, and 96 hours after the initial exercise. Comparisons were made at all time points using a bootstrapping method of 95% confidence intervals for each measure. **Results**: Sta-tistically significant differences were found between groups when the confidence intervals did not overlap. The only variables where CIs did not overlap were calf girth and self-reported function. The ice group had decreased calf girth compared to the control group at 48 hr (Ice: 33.7cm (32.9 - 34.4); Control: 35.4cm (34.7-36.2)), 72 hr (Ice: 33.9cm (33.0-34.7); Control: 35.6cm (34.8-36.3)), and 96 hr (Ice: 33.6cm (32.9-34.3); Control: 35.5cm (34.6-36.3)). However, girth for the control group at baseline was slightly higher than the cryotherapy group and girth at 48, 72, and 96 hours did not change from baseline for either group. The ice group also had decreased self-reported function at 10 hours compared to the control group (Ice: 93% (94.1-98.4); Control:99.4% (98.8-100.0)). **Conclusions**:While statistically significant, there were no clinically important differences between groups on the treatment of DOMS. Sequential cryotherapy treatments, initiated immediately after eccentric exercise, did not affect outcomes of pain, point tenderness, ROM, strength or function.

Blood Lactate Responses to Cold Water Immersion and Biking compared to Controls in Professional Ice Hockey Players after High Intensity Skating

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Context: Blood lactate recovery is important after high-intensity anaerobic exercise common to ice hockey. Previous research has investigated the effects of biking or cold-water immersion versus controls on post exercise recovery of blood lactate. However, a comparison study

of cold-water emersion and biking treatments on blood lactate have not been evaluated in professional ice hockey players. **Objective:** To examine the effects of cold-water immersion (CWI), stationary cycling (Bike), and seated recovery (Control)after high-intensity skating on blood lactate levels immediately prior to treatment (pre-treatment) and at 5 (5-post), 10 (10-post) and 15 (15-post) min post treatment. We hypothesized that Bike would produce a greater reduction in blood lactate compared with CWI orControl. **Design:** Randomized Control Clinical Trial.**Setting:** Professional ice hockey training facility. **Patients or Other Partici-pants:** Sixty professional ice hockey players (age: 24.1 ± 5.2y weight: 90.5±7.5kg and height: 185±5.4cm) randomly divided into three experimental groups participated in the study. **Interventions:** Blood lactate was measured via fingerstick technique prior to and then immediately following an anaerobic on-ice 3 min skating test in full hockey equipment. After exercise, players immediately returned to the locker-room, removed their equipment and reported to their assigned treatment which was either Control (15 min seated rest), CWI (8 min cold water at 11pC immersion to ASIS level and then 7 min standing) or Bike (15 min stationary cycling at 70% MHR). Blood lactate was measured by lactate analyzer (Accutrend) before and after exercise, and then immediately before treatment (pre-treatment) and at 5-post, 10-post and 15-post initiation of treatment. **Main Outcome Measures:** Blood lactate (mmol• l^{-1}).**Results:** No differences in physical characteristics were found between groups. Blood lactate increased from baseline (3.1 ± 1.3 mmol•l^{-1}) to post-exercise (11.4 ± 4 mmol•l^{-1}), P< 0.001, however no differences were found between groups at baseline or post-exercise.At 5-post blood lactate was different from Control (9.7 ± 2.4 mmol•l^{-1}) in Bike (7.9 ± 2.5 mmol• l^{-1}) and CWI (7.7 ± 2.1 mmol•l^{-1}), P=.01. There were no group differ-ences at 10-post, P=.08, and only Bike (5.9 ± 2.6 mmol•l^{-1}) was different from Control (8 ± 2.1 mmol•l^{-1}) at 15-post, P = .02. **Conclusions:** The results suggest that after 5 min of treatment both biking and cold-water immersion facilitate a greater reduction in blood lactate compared to seated rest. After 15 min of treatment, only Bike was significantly different from Control, however, our research protocol included only 8 min of CWI because it is the typical length of time these players remain in cold water post exercise. Both Bike and CWI appear to facilitate the removal of lactate from the blood after high-intensity skating in elite ice hockey players however, additional research should evaluate a longer period of time for CWI post exercise.

Impact of Mental Toughness Training on Psychological and Physical Predictors of Illness and Injury

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Context: Intense training for prolonged periods of time without adequate recovery can result in psychological problems and increased susceptibility to illness and injury in collegiate athletes. Mental toughness, the ability to perform in the upper range of one's ability regardless of the situation, is a modifiable psycho-logical construct that can influence cognitive appraisal, and is one of the most important characteristics that an athlete can possess. Altering an athlete's interpretation of stressful situations through mental toughness training could potentially change how the athlete evaluates his/her ability to handle the stressors of training and competition, and may attenuate the negative psychological outcomes that are associated with increased risk of developing illnesses and injuries. **Objective:** To implement a 6-week personalized Mental Toughness Training Program and evaluate its impact on mental toughness, mood state, depression, perceived stress, physical symptoms, and athlete burnout in Division III athletes. **Design:** Randomized nested design. **Setting:** Smith College (Division III private institution). **Patients or Other Participants**: 36 female student athletes (19.3±1.4 years old)on the Smith College varsity Field Hockey (n=15) and Soccer (n=21) teams. **Interventions**: Participants were randomly assigned by team to the 6-week Mental Toughness Training Program (field hockey) or wait-list control condition (soccer). The Mental Toughness Training Program involved daily psychological skills training completed online. Participants completed questionnaires assessing mental toughness (MeB-Tough), mood state (Profile of Mood States), depression (Beck Depression Inventory), perceived stress (Perceived Stress Scale), physical symptoms (Cohen-Hoberman Inventory of Physical Symptoms), and burnout (Athletic Burnout Questionnaire) prior to and at the conclusion of the program. **Main Outcome Measures**: Total scores from the six questionnaires were compared to determine if the Mental Toughness Training Program improved mental toughness, mood state, depression, and perceived stress and reduced physical symptoms and burnout. A Repeated Measures ANOVA was used to evaluate the effectiveness of the program. **Results**: Mental toughness levels were significantly increased in the intervention group (F=7.08,p=.01), and the training led to significant reductions in total mood disturbance (F=5.98,p=.02), depression (F=4.87, p=.04), and total number of physical symptoms experienced (F=5.77, p=.02). Perceived stress and athlete burnout were not significantly changed by the training. **Conclusions**: The Mental Toughness Training Program led to an increase in mental toughness levels, and was able to significantly reduce levels of mood disturbance, depression, and physical symptoms in Division III female athletes. These findings show that mental toughness training had a positive effect on psychological and physical variables that have been associated with increased risk of injury and illness in collegiate athletes. Further research examining how mental toughness training affects psychological and physical variables in other samples (males, Division I athletes) is warranted. Funded by the NATA Foundation Masters Grant Program.

The Mental, Emotional and Bodily Toughness Inventory (MeBTough): Construct Validity Evidence

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Context: Mental toughness, the ability to perform at one's best regardless of the circumstances, is a modifiable cognitive trait and an essential psychological attribute for successful athletes. The Mental, Emotional, and Bodily Toughness Inventory (MeBTough) is a recently developed measure of mental toughness with good psychometric properties. However, additional validity evidence for the MeBTough is needed. **Objective:** To provide evidence of construct validity for the MeBTough by examining the relationship between mental toughness and other psychological (mood state, depression, perceived stress, athlete burnout) and physical (physical symptoms) variables that are associated with successful sport performance.**Design:** Cross-sectional study. **Setting:** Smith College (Division III private institution). **Patients or Other Participants**: 47 female student athletes (19.3±1.4 years of age) on Smith College varsity athletic teams. **Interventions**: Participants completed the MeBTough, along with measures of mood state (Profile of Mood States), depression (Beck Depression Inventory), perceived stress (Perceived Stress Scale), physical symptoms (Cohen-Hoberman Inventory of Physical Symptoms), and athlete burnout (Athletic Burnout Questionnaire). **Main Outcome Measures**: Spearman Rho correlations were calculated among the scores from the measures to determine if mental toughness is

associated with these psychological and physical variables.The MeBTough was expected to have negative correlations with mood disturbance, perceived stress, depression, burnout, and physical symptoms, and finding such relationshipswould provide evidence of construct validity for the measure. **Results**: Mental toughness was significantly correlated with total mood disturbance (ρ=-.51 p<.001), depression (ρ=-.49, p<.001), perceived stress (ρ=-.53,p<.001), and athlete burnout (ρ=-.46, p=.001). Total number of physical symptoms was not significantly correlated with mental toughness, but it did have significant positive correlations with all of the other measures. **Conclusions**: Higher levels of mental toughness were associated with lower levels of mood disturbance, depression, perceived stress, and athlete burnout in Division III female athletes. These findings provide additional construct validity evidence for the MeBTough, and indicate that the MeBTough provides a good assessment of mental toughness.

Examining the Experimental Designs and Statistical Analyses of Athletic Training over the Past Six Years

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Context: The most common method to analyze data from longitudinal designs in athletic training is with the repeated measures analysis of variance (RM ANOVA). There may be concern with this analytical technique due to the numerous assumptions that must be met for the results to be valid. **Objective**: The purpose was to examine an alternative statistical method for data from longitudinal designs in athletic training compared to the traditional RM ANOVA. I proposed using the hierarchical linear model (HLM) which has been more commonly used, with success, in other health care fields. Using the HLM allows for more detailed research questions to be answered because of the ability to examine the individual growth trajectories as opposed to simply comparing group means. This statistical analysis also does not possess the strict assumptions that the RM ANOVA does. **Data Sources**: All original research articles published in the *JAT* from 2005-2010 (N=218) were coded for general research design according to the new nomenclature set forth by the editorial board and Dr. Hertel in the *JAT* May 2010 issue. Secondly, the same studies were coded for a more specific design (longitudinal, pre-post, repeated measures, or other). **Study Selection**: From this classification, 52 of the 218 studies were longitudinal designs. Fifty of the 52 studies used the RM ANOVA to analyze the data. More specifically, 24 of the 52 longitudinal studies were classified as crossover studies using Dr. Hertel's nomenclature. These 24 studies served as the sampling frame for the data collection of this work. **Data Extraction**: Through a random sampling procedure, 18 corresponding authors were contacted through e-mail. Nine authors were willing to provide the de-identified data requested for the first RM ANOVA presented in the journal article. **Data Synthesis**: All 9datasets were coded to insure confidentiality. Following descriptive statistics, the RM ANOVA was completed as described in the published article. The reanalysis results were then compared with the findings presented in the *JAT*. Only 1 of the articles mentioned assumption testing. In all nine datasets, the assumption of sphericity was violated yet the analysis continued. Next, an HLM was used to reexamine the same data. The HLM reanalysis revealed that the data could be more appropriately modeled since only 1 of the datasets was linear. This allowed for more detailed research questions to be answered such a show did individuals growth trajectoriesin the treatment condition compare to the control condition. **Conclusions**: The major finding of this work was that in the past 6 years, many authors are utilizing the RM ANOVA and violating important assumptions that must be met. By using the HLM, more detailed research questions can be answered without the strict assumptions as seen in the RM ANOVA.

The Use of a Customized, Web-based Electronic Medical Record by Athletic Trainers in the Secondary School Setting: Preferences, Usability, and Barriers to Use

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Context: National recommendations call for clinicians to document patient care using electronic medical records (EMR). Clinician preference, perceived usability, and barriers to the use of EMRs impacts adoption and should be routinely assessed to optimize utilization. **Objective:** Assess athletic trainers' (AT) preferences and perceived usability of current and proposed EMR components on clinical practice, and identify barriers to routine EMR use. **Design**: Cross-sectional. **Setting**: Web-based survey of secondary school ATs utilizing a custom web-based EMR. **Patients or Other Participants:** Of the 25 ATs using the custom web-based EMR for at least 1 year in a secondary school setting, a voluntary sample of 22 (88%) completed the survey (male=8; female =14; age=25.4±3.0 yrs). **Interventions:** The survey contained 25 questions in 5 categories: demographic, perceived usability of current EMR components, perceived usability of EMR on job performance, perceived usability of proposed EMR components, and perceived barriers to EMR use. **Main Outcome Measures:** Dependent variables were: perceived usability or barrier, measured as the degree to which respondents agreed or disagreed with statements using a Likert Scale ranging from 1 (strongly

disagree) to 5 (strongly agree). A descriptive analysis was used to report responses. **Results**: Seventeen (77.3%) respondents held a bachelor's degree, 19 (86.4%) were AT certified <4 yrs, and 16 (72.7%) had previous EMR experience. The majority of respondents (71.9%) "agreed"/"strongly agreed" that each of the 12 current EMR components was useful in practice. The most useful components were: injury evaluation forms (4.1±0.7); injury demographic forms (3.9±0.8); daily patient sign-in sheets (3.9±0.9); and, daily treatment progress notes (3.8±0.9). The least useful features were the automated diagnostic (ICD-9) and treatment (CPT) codes (3.2±1.3). The majority of respondents (57.6%) "agreed"/"strongly agreed" that the EMR enhances effectiveness, improves job performance, makes doing the job easier, and is generally advantageous to the job. Clinicians rated the EMR's ability to help accomplish work tasks more quickly as 2.7±1.1, with 7 (31.8%) agreeing and 10 (45.4%) disagreeing. Perceived usefulness of 8 proposed EMR components was greatest for: patient registration (4.5±0.8); coach reports (4.4±0.5); "quick" notes tool (4.2±0.7); and body region evaluation forms (4.2±0.9). Primary barriers to routine EMR use were: form length and/or completion times (3.9±0.9 to 4.1±0.8); patient non-compliance with form completion (4.1±.09); and peers/co-workers not using the EMR (3.5±1.2). Internet and/or computer access (2.1±1.3 to 2.5±1.1) were not identified as obstacles to routine EMR use, although additional computers would improve utilization (3.4±1.4). **Con-clusions:** The custom web-based EMR was perceived as useful and beneficial to clinical practice. Primary barriers to EMR use in the secondary school setting are time/length of required elements and social influences, which are potentially modifiable factors. Consistent with national healthcare recommendations, ATs should be encouraged to document patient care using an EMR.

Riding Hand Effect on Postural Sway and Center of Gravity in Professional Rodeo Cowboy's Association Bull Riders

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Context: Bull riding requires great skill and strength and is one of the most dangerous sports in which to compete. To stay atop a bucking bull, a bull rider's center of gravity (COG) must be maintained over the bull. A compromised COG could place the rider at a great disadvantage and at increased risk for injury due to an unplanned dismount. Anecdotal beliefs amongst bull riders suggest that bull riding handedness may play a role in altering COG. **Objective:** The purpose of this study was to determine if preferred riding hand had an effect on COG or postural sway (PS) in professional bull riders. **Design:** Field Laboratory. **Setting:** Balance tests along with a riding preference questionnaire were completed at the San Antonio Rodeo and Stock Show. **Patients or Other Participants:** Twenty-two male Professional Rodeo Cowboy's Association Bull Riders (weight=70.94±7.08kg; height = 69.1±2.6 cm; age = 24±3.02 years; professional rodeo experience = 5.9±2.9 years; total rodeo experience = 14.2±4.7 years) volunteered to participate in the study. **Interventions:** Participants were tested for PS and COG with the modified Clinical Test of Sensory Integration and Balance (m-CTSIB) test of the Biodex Balance System SDin an unshod bipedal stance under four testing conditions with three, 20-second trials: eyes open firm surface, eyes closed firm surface, eyes open foam surface and eyes closed foam surface. Participants also completed a three question survey about riding technique. **Main Outcome Measures:** Two judges independently coded the PS plots (κ=1.00) to establish COG location by analyzing the plots and classifying the participant's COG as "right" or "left" sided. To understand the effect of handedness on COG, a 2X2 Chi square analysis was performed for each balance condition. PS was established using a postural sway index from the m-CTSIB. To understand the effect of handedness on postural sway index, the authors ran 4 separate independent samples t-test for each balance condition. A Bonferroni correction for multiple comparisons used for an a priori level of significance of p=0.0125. **Results:** There were no differences between right and left handed rodeo athletes in regards to the postural sway index. T-tests results under the eyes open firm condition (t_{20}=2.432, p=0.042), eyes closed firm condition (t_{20}=1.350, p=0.216), eyes open foam surface (t_{20}=1.064, p=0.300), and eyes closed foam (t_{20}= -0.396, p=0.696) surface were not significant. There were no differences in center of gravity plots between right and left handed bull riders under the eyes open firm condition (χ^2=2.148, p=.143), eyes closed firm condition (χ^2=0.42, p=0.838), eyes open foam (χ^2= 0.003, p=.958), and eyes closed foam condition (χ^2= 0.003, p= .958). **Conclusion:** No relationship existed between handedness and balance in this study, but further research on balance in functional positions should be conducted.

A Comparison of Traditional and Modified Volumetric Techniques

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Context: Water volumetry is considered the "Gold Standard" for girth assessment in clinical health care practices. Volumetry allows the clinician to monitor changes in swelling (an indicator of tissue healing) and make appropriate treatment decisions. Traditional water volumetry involves immersion of a body segment (e.g., ankle, arm) into a container of water and measurement of the displaced water via graduated

cylinders. Accuracy of these measurements is limited by the quality and readability of the graduated cylinders. **Objective**: The purpose of this study was to compare a modified protocol to traditional water volumetry. **Design**: Reliability study. **Setting**: Research laboratory. **Patients or Other Participants**: 2 examiners (mean age = 25 years) with no previous volumetric assessment experience performed measurements on 26 volunteer models. **Interventions**: Independent variables were examiners (E1, E2) and volumetry protocols (modified, traditional). The same volumetric tank was used for all measurements (Foot Model; Wisdom King, Oceanside, CA). Traditional volumetry (TRD) required the displaced water to be transferred from the collection vessel to a standard 500 mL graduated cylinder (with 5 mL increments) for measurement. The modified protocol (MOD) involved weighing the displaced water with a standard digital scale (CHAMP II, OHAUS, Pine Brook, NJ) instead of graduated cylinders. Each examiner was provided with instructions and demonstrations of both protocols, familiarized with equipment, and practice opportunities. Feedback and corrections were provided only during practice trials. Each examiner performed three trials of both protocols on the same ankle of the volunteer models. The order of volumetry protocol was randomized for each model. **Main Outcome Measures**: Dependent variable: displaced water (mL). Intrarater (IAR) and interrater (IER) reliability for each protocol and between protocols were evaluated using intraclass correlation coefficients formula ICC (2,1). In addition, the standard error of measurement (SEM) was calculated for each protocol. **Results**: All values presented as mean ±SD (mL). IAR and IER were found to be very high: IAR E1 MOD (474.84 ±171.5 mL), ICC = .99; TRD (487.82 ±174.5 mL), ICC = .99; E2 MOD (475.98 ±170.7 mL), ICC = .99, TRD (487.24 ±174.8 mL), ICC = .99; IER MOD (E1 474.84 ±171.5, E2 475.98 ±170.7 mL), ICC = .99; TRD (E1 487.82 ±174.5, E2 487.24 ±174.8 mL), ICC = .99; between MOD (475.41 ±171.0 mL), TRD (487.53 ±174.6 mL), ICC = .99. The SEM calculated for MOD was 5.41 mL and 9.56 mL for TRD. **Conclusions**: Our results indicate the modified volumetry protocol provides measurements that are very similar to the traditional "Gold Standard" technique. Moreover, the smaller SEM calculated for the modified protocol indicates measurements are closer to actual values than the traditional technique. Empirical evidence suggests that the modified protocol requires less equipment, consists of fewer steps, and could effectively replace traditional volumetry assessment.

Test Re-Test Reliability of on Ice Exercises for Functional Ice Hockey Return to Play Battery

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Context: Functional screening tests have been established for ice hockey, but it is unknown if they are specifically used as criteria for return to play. The on ice activities established in the functional ice hockey return to play battery has been used as criteria for return to play but reliability for this test is unknown. **Objective**: To establish reliability for the Functional Ice Hockey Return to Play Battery (FIHRPB). **Design**: A prospective test re-test design. **Setting**: A Division I club ice hockey team. **Patients and Other Participants**: A total of 23 participants from a D-I club hockey team (age= 20.39±1.85 yrs, mass= 81.23±6.69 kg, height=184.01±5.10 cm)) volunteered. All participants included in the study encompassed a variety of ice hockey positions that were free of lower extremity injury for the previous 6 months. **Interventions**: The participants were asked to complete the on ice tests in the FIHRPB which included the Acceleration test, Top Speed test, S cornering test, On Ice Quickness, On Ice Leg Quickness and Pivot Test. All tests were completed in full pads with sticks to simulate game situation and speed. Each test was completed three times with a 30 second rest between trials and each successive task. Data was collected at the site over two separate three week periods. For each testing session, the first week consisted of a training session followed by the second week of data collection and then another data collection a week later. Intraclass Correlation Coefficients ($ICC_{3,1}$) was used for test-retest reliability, with Standard Error of Measurement (SEM) and Methodological Error. **Main Outcome Measures**: Three maximal attempts with the best time recorded in seconds for the Acceleration test, Top Speed test, S cornering test, On Ice Quickness, On Ice Leg Quickness and Pivot Test. **Results**: The S Cornering Test had the highest ICC ($ICC_{3,1}$=.882, SEM = .104 sec) followed by the Top Speed test ($ICC_{3,1}$ =.841, SEM=.155 sec), On Ice leg Quickness Test ($ICC_{3,1}$= .780, SEM=.220 sec), the Pivot Shift ($ICC_{3,1}$= .778, SEM=.165 sec), and the On Ice Quickness test (ICC3,1 = .721, SEM=.098 sec). The lowest ICC was for the Acceleration Test ($ICC_{3,1}$ = .608, SEM= .06 sec). Methodological error ranged from .018% to .38%. Based on the low SEM results, there would be minimal variation of the measurements expected on a day to day basis. **Conclusion:** The exercises established in FIHRPB are reliable tests when used for return to play from ice hockey injuries. Further research needs to be conducted on the validity of FIHRPB since moderate to good reliability was established with low methodological error.

Tracking Distance in Division I Men's Soccer: A Comparison of Global Positioning Systems

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Context: Calculating distance covered (DC)during team sports such as soccer is important to athletic trainers, coaches, and researchers when estimating or obtaining specific training volumes, athletic performances and rehabilitation goals. Previously this calculation of DC has proven difficult to obtain. Due to recent technological advances in the area of global positioning systems (GPS), the ability to measure distance in a team sport setting is now feasible. Currently, no research exists comparing different GPS measurement devices during Division I soccer. **Objective:** The purpose of this observational research was to describe the accuracy and compare two common GPS devices currently on the market (one less expensive$300/unit, and one expensive $2000/unit), used for quantifying exercise distance. **Design:** Observational field research. **Setting:** Outdoor soccer field. **Patients or Other Participants:** Twenty-one male NCAA Division I soccer players (age, 20± 1y; height, 187.5± 2cm; mass, 76.2 ± 5.6kg) **Interventions:** Participants completed six practices (98.9 ±21.9min) and one game(113 min)on a standard grass soccer field. DC was collected using two different GPS devices, the less expensive Timex Global Trainer®(GT) and the more expensive Catapult Minimax®(MM). Additionally, accuracy was determined in a separate pilot testing session on a standard outdoor running track with all subjects running in the innermost lane. **Main Outcome Measure:** Paired sample t-tests were performed to analyze differences between mean DC as measured by both GPS devices. Alpha level was set at 0.05 *a priori.* **Results:** The accuracy of GT was (-0.02km; 95%CI -0.09 to 0.05) and MM was (0.01km; 95%CI -0.05 to 0.07). The DC measured with the two devices was similar (p = 0.11).Mean total DC for the six practices, one game, and combined practices and game as indicated by the GT was (10.0± 2.34km, 11.15± 3.73km, 10.17± 2.60km) respectively, and for MM (9.30± 2.35km, 11.27± 5.54km, 9.60 ± 3.07km). The % change between MM and GT were (-7.5, 1.0, -5.9%) for practices, game, and practice/game combined. MM-GT mean differences for DC in practice, game and practice/game combined were (-0.70± 0.66km,p ≤ .05; 0.12 ± 2.05km, p = 0.84;-0.56± 1.02km; p ≤ .05), respectively. Correlations between the devices for practice, game and practice/game combined were r^2=(0.96, 0.98, and 0.93), respectively. **Conclusion:** The distances reported by the two devices were similar during the game, however during practice and practice/game combined comparisons, the devices were found to be significantly different. It should be noted that clinically the differences between the two devices are very small indicating that they are useful measurement tools for determining distance, performance and training volume.

Validation of an Algorithm to Predict Ovulatory Status at the Time of Injury

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Context: Women are 2-8 times more likely to sustain an anterior cruciate ligament (ACL) injury than men. The mechanisms for this disparity are unclear. There is consensus in the literature that women are at increased risk of injury during the pre-ovulatory phase of their menstrual cycle (MC), however, prior investigations often lacked validated assessment tools to characterize MC phase. **Objective:** To evaluate the accuracy, sensitivity, and specificity of an algorithm designed to retrospectively classify an athlete's MC phase at the time of a "mock" injury based on historic MC information and salivary progesterone (P4) concentration. **Design:** Prospective cohort with nested retrospective assessment of MC phase. **Setting:** Academic research laboratory. **Participants:** Thirty-one healthy, female collegiate athletes (18-24 years) with normal MC history and no prescription medications including hormonal contraception. **Interventions:** Subjects attended 8 visits over one completeMC, with one visit randomly assigned as the mock injury date. Saliva samples were obtained at each visit, and serum samples obtained every other visit. Ovulation date was ascertained with daily urinary LH detection tests and serum P4. MC information was acquired by an investigator blinded to all other aspects of the study via a Hormonal History Questionnaire (HHQ) administered at a randomized time point (1-45 days)after the mock injury date. At the completion of data collection, four clinical experts examined HHQ information and a single salivary progesterone concentration obtained after the mock injury. They then retrospectively classified each subject's MC phase at the time the mock injury occurred (consistent with case-control investigations). Expert and algorithm classification results were compared using Kappa statistics. Sensitivity and specificity were determined by comparing classification results to known MC phase at the time of the mock injury based on ovulation date. **Results:** Fourteen subjects (45%) had an ovulatory cycles; consequently, only 2 subjects were confirmed to be post-ovulatory at the time of their assigned mock injury date. The algorithm correctly classified MC phase at the time of mock injury for

74%of subjects, with 76% specificity and 50% sensitivity for the pre-ovulatory phase. The experts correctly classified MC phase for 71-74% of subjects, with 72-76% specificity and 0.50-1.00% sensitivity. Agreement between expert and algorithm phase classifications ranged from 81% (Kappa = 0.50) to 93% (Kappa = 0.83). **Conclusion:** The algorithm and experts did not accurately predict MC phase at the time of injury. Sensitivity of the post ovulatory phase could not be adequately assessed due to the high number of anovulatory cycles, and consequently low number of subjects with mock injury dates in the post-ovulatory phase. Our findings raise questions regarding the accuracy of MC phase classification of young athletes in other investigations, particularly in a population with a high occurrence of anovulatory cycles.

The Acquisition, Retention, and Application of Knowledge Following a Conference Workshop Attended by Athletic Trainers

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Context: Continuing education is required for athletic trainers (ATs) to maintain their credential yet little is known regarding its efficacy and application to clinical practice. **Objective:** To assess ATs' acquisition, retention, and application of knowledge following a conference workshop. **Design:** Cohort pre-test, post-test design. **Setting:** Differential diagnosis of the hip joint workshop presented at the Mid America Athletic Trainers' Association Annual Meeting. **Patients or Other Participants:** A sample of 23 ATs (10 female, 13 male; age 36.6 ± 9.6) who registered for the workshop and volunteered to participate in the study. **Interventions:** An eight-hour workshop including lecture and hands-on lab activities was experienced by the participants. A 10-item multiple-choice exam was created by the workshop instructor specifically for the workshop and its content was validated by an expert panel. The exam was administered at three time points: prior to (baseline), immediately following ($posttest_1$), and 4-weeks after the workshop ($posttest_2$). A 3-item survey with five responses ranging from "strongly agree" to "strongly disagree" was used to obtain an understanding of the participants' application of the knowledge gained from the workshop. This survey was administered at the same time as $posttest_2$. The survey's content validity was examined by a three member panel. **Main Outcome Measures:** We used separate paired-sample *t* tests to compare mean pre-test and $posttest_1$ exam scores to determine knowledge acquisition as well as mean $posttest_1$ and $posttest_2$ exam scores to determine knowledge retention. Our a priori level was set at $P=<.05$.The knowledge application survey responses were analyzed with descriptive data. **Results:** Mean knowledge scores increased significantly from baseline (6.22 ± 1.35) to $posttest_1$ (7.44 ± 1.24), $t(22)=3.88$, $P=.001$ (effect size, $d=.90$). Participants retained their knowledge as the mean $posttest_2$ score (7.22 ± 1.48) was not significantly different from the $posttest_1$ score, $t(8)=0.61$, $P=.559$. The survey results indicated that 89% (n=8/9) of participants agreed that not only did they retain their knowledge and skills, but they were also able integrate those skills into clinical practice and improve patient care. **Conclusions:** The eight-hour workshop with combined lecture and hands-on activity was effective in facilitating the acquisition and retention of these ATs' knowledge and skills, which were applied to clinical practice to improve patient care.

Frustrations Among Graduates of Athletic Training Education Programs

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Context: Although previous research has begun to identify sources of athletic training student stress, the specific reasons for frustrations that occur while students are completing an athletic training education program (ATEP) are not yet fully understood. It is important for athletic training educators to understand sources of student frustration to provide a supportive learning environment. **Objective:** To determine the factors that lead to feelings of frustration while completing an entry-level ATEP. **Design:** We used qualitative methods to gain rich description of the factors involved in student frustration while completing an ATEP. **Setting:** National Athletic Trainers' Association (NATA) accredited Post-Professional Education Program. **Patients or Other Participants:** Fourteen (12 female, 2 male; age = 22.21±1.05 years) successful graduates of accredited undergraduate entry-level ATEPs currently enrolled in an NATA accredited Post-Professional Education Program volunteered to participate. The participants graduated from 14 different ATEPs located in 6 out of the 10 NATA districts. The participants' ATEPs also represented all three major Carnegie classifications (6 from research institutions, 6 from master's institutions, and 2 from baccalaureate institutions).**Data Collection and Analysis:** We conducted semi-structured interviews, transcribed the interviews verbatim, and analyzed data with a grounded theory approach utilizing open, axial, and selective coding procedures. We used NVivo (version 8, QSR International Pty Ltd, Cambridge, MA)computer software to facilitate the coding procedure. To ensure trustworthiness of the data, we negotiated over the coding scheme until we came to agreement, completed peer debriefs, and performed member checks. **Results:** Four themes emerged from the data. Athletic training student frustrations appear to stem from the amount of *stress* involved in completing an ATEP leading to anxiety and feelings of being overwhelmed. The *interactions* students have with classmates, faculty, and ACIs can also be a source of frustration for AT students. *Monotonous clinical experiences* often left students feeling disengaged. Students questioned entering the profession of AT because of the fear

of *work-life balance* problems and low compensation. **Conclusions:** Based on our results, we believe frustrations can be avoided by providing a supportive learning environment for athletic training students. Instructors should support their students by validating their membership in the ATEP as this validation will help students to understand their roles and thrive in the educational program. Faculty, staff and ACIs are encouraged to communicate effectively and make student expectations clear as this practice will help to motivate students to persist. Providing students with appropriate clinical education experiences that are characterized by graded autonomy can keep learning exciting. Finally, we believe that student interactions with professional mentors and role models that highlight the dynamic nature of the athletic training field will foster feelings of excitement about pursuing a career in athletic training.

Entry-Level Athletic Trainers' Perceived Adequacy of Clinical Education in Preparation for Confident Professional Practice

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Context: Athletic training clinical education research is primarily centered on clinical instructors and charac-teristics of clinical settings, with a paucity of data focused on the athletic training student as a learner within the clinical setting. Athletic training students' perception of clinical education adequacy has been largely ignored. **Objective:** To examine the perceptions of newly certified athletic trainers (ATs) regarding the adequacy of their clinical education in preparation for confident entry-level professional practice. **Design:** Cross Sectional. **Setting:** Online survey. **Participants:** A sample of 1920 email addresses of newly certified ATs was obtained from the National Athletic Trainers' Association. Newly certified AT were considered to be within two years post-graduation from an entry-level CAATE accredited program and currently employed as an AT. A total of 428 ATs (n=136 males, n=292 females) responded, producing a response rate of 25%. **Interventions:** Respondent's sex, grade point average (GPA), and Board of Certification (BOC) exam attempts were recorded. A perceived adequacy and confidence to practice questionnaire using a 5-point Likert scale was constructed based around the professional practice domains. An expert panel examined the validity of the instrument. A test re-test reliability pilot study was conducted with a convenient sample of 45 athletic training graduate students. Pilot data analysis revealed Cronbach's alpha 0.86 and interclass correlation of 0.87. The survey was administered using SurveyMonkey and was distributed by initial and follow-up e-mails. **Main Outcome Measures:** Responses were scored and transformed into 'adequate/confident,' 'neutral,' or 'inadequate/not confident.' Scores were totaled for perceived adequacy and confidence to practice athletic training, along with each professional practice domain. Descriptive statistics were used to evaluate the adequacy and confident percentages. Pearson correlations evaluated the relation-ships between overall adequacy and confidence. **Results:** Three hundred seventy-three (87.1%) respondents perceived their overall clinical education adequate and 414 (96.7%) felt confident to practice athletic training. The relationship between perceived adequacy and confidence to practice AT was significant (r =0.74; P<0.05). The highest adequacy rating among the professional practice domains were; prevention 393 (89.7%), evaluation and diagnosis 396 (90.4%), immediate care 387 (88.4%), and treatment, rehabilitation and reconditioning 364 (83.1%). Showing highest inadequacy rating were 'organization and administration' 46 (10.5%) and 'professional re-sponsibility' 39 (8.9%) respondents. The overall sample mean GPA was 3.47±0.30 and BOC attempts ranged from one to more than four, 299 (69.9%) passed in one attempt, 74 (17.3%) two, 33 (7.7%) three, 13 (3%) four and 9 (2.1%) in more than four attempts. **Conclusions:** Entry-level ATs appear satisfied with their clinical education preparation. Respondents felt the least adequately prepared in the professional practice domain of 'organization and administration. The results suggest that athletic training students are receiving adequate clinical education experience, which establishes confidence to practice athletic training after graduation.

Clinical Satisfaction Levels of National Athletic Trainers' AssociationAccredited Post-Professional Athletic Training Graduates

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Context: Limited information exists concerning the satisfaction of graduates from National Athletic Trainers' Association Accredited Post-Pro-fessional Athletic Training Education Programs (PPATEP) related to clinical education. Outcome measuresof satisfaction scores are necessary to evaluate the clinical aspects of these programs. **Objective:** To **i**dentify various aspects of clinical satisfaction for 2009-2010 graduates of NATA Accredited PPATEPs. **Design:** Cross-sectional. **Setting:** Online survey instrument. **Patients or Other Participants:** Electronic mail addresses for the 2009-2010 PPATEP graduates (n = 307) were gathered from the NATA online member directory database. Of the 307 graduates, 40 e-mail addresses were either invalid or unobtainable, therefore 267 graduates were invited to participate. One hundred six(65 female: age= 24.91 ±1.7yrs; 41 male: age =26.05 ±2.25 yrs) graduates (2009

graduates = 50; 2010 graduates = 56) completed the survey (39.7% response rate). **Intervention:** An initial email that contained a description of the importance of the research study, the URL survey hyperlink, the estimated time to complete the survey (30 minutes), and a request for partici-pation was sent to participants with a follow up e-mail sent out once per week for the four weeks of data collection. The survey instrument was created using Inquisite 9.5 Corporate Survey Builder. **Main Outcome Measures:** Demographic information and satisfaction scores (Likert scale 1-5) related to components of the clinical education plan were obtained and analyzed using SPSS (Version 17.0, PASW Inc. Chicago IL). This information related to supervision levels and contact time with clinical staff, hours spent within clinical practice, formal and informal feedback received about performance during the clinical experience and mentorship received from the primary mentor. Nonparametric statistics were used to assess relationships and differences ($p<.05$). **Results:** All graduates of 2009 and 2010 NATA Accredited PPATEPs were found to be at least very satisfied (4.27/ 5.0±.91)with their overall clinical education plan. There were no differences in overall satisfaction scores between number of hours per week (<20 or >20) spent at the clinical placement ($p=0.142$). A positive correlation ($r=.287$, $p=.003$) was found between level of satisfaction with formal and informal feedback about performance during the clinical experience and how often participants had direct contact with their clinical supervisor. A positive correlation ($r=.510$, $p= <.001$) also existed between the level of satisfaction with the mentorship that participants received from their primary clinical mentor and how often participants had direct contact with their clinical supervisor. **Conclusions:** These results suggest that graduates of NATA Accredited PPATEPs are generally satisfied in most areas of their clinical education, however satisfaction in areas such as mentorship received from the primary clinical mentor and formal and informal feedback received about performance at the clinical placement are deficient. Future research should involve the examination of strategies to improve clinical mentorship and feedback for PPATEP students.

The Impact of Clinical Reasoning Skills on BOC Examination Performance

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Context: Athletic Training candidates face a challenging task on the path to becoming a certified athletic trainer. Uncertainty surrounds the professional community as to why certain candidates, who otherwise perform soundly both academically and clinically, struggle to be successful on the certification exam. Clinical reasoning skills are at the heart of judicious athletic training practice and entry into this practice. The assessment of clinical reasoning skills is an important facet of understanding why certain candidates fail to pass the national certification exam in Athletic Training. **Objective:** The purpose of this study is to determine whether clinical reasoning skills, as measured by the Health Sciences Reasoning Test© (HSRT), is correlated to BOC™ certification exam performance for Athletic Training candidates. Further, does subscale performance on the HSRT© in the areas of inductive reasoning, deductive reasoning, analysis, inference, and evaluation predict a candidate's certification exam score. **Design:** Non-experimental design. **Setting:** Self-reported online instrument. **Patients or Other Participants:** A total of 71 candidates taking the BOC™ exam for the first time in June 2011(47 females; 24 males; Age= 22.77± 1.758 years). **Interventions:** All the candidates completed the online HSRT©. Participants self-reported their BOC™ exam scores and other demographic information (level of ATEP, GPA, age, sex, time spent weekly studying for exam).**Main Outcome Measures:** The dependent variable was BOC™ score and the independent variables were HRST© sub-scale scores. A simultaneous multiple regression analysis was conducted to determine which of the HSRT© sub-scales were significant predictors of BOC™exam performance. **Results:** Correlation analysis revealed that deductive reasoning, analysis and interpretation, and inference scale scores were significantly and positively related to BOC™ exam score. Correlations were moderately low (r=.29-.35).The multiple regression was significant*:* $F(5,65)=3.49$, $p<.01$, with 21% of the variance being explained by HRST sub-scale scores. The inference scale score emerged as the only significant predictor of BOC™ exam score (β=.36). Thus, higher performance on the inference scale predicted higher BOC™ exam scores. **Conclusions:** The results indicate that the clinical reasoning skill of inference is a strong predictor of BOC™ exam performance. Inference skills are used to identify and secure elements needed to draw reasonable conclusions, to form conjectures and hypotheses. Therefore, AT educators should focus more of their instructional energies on clinical case studies as a means to develop and foster clinical reasoning skills.

Predicting Athletic Training Students' Commitment to ATEP

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Context: In order for athletic training students to be successful in any athletic training education program (ATEP), a certain level of commitment to the program and profession is required. According to the Sport Commitment Model (SCM), commitment to an activity can be determined based on specific predictors, including enjoyment, investments, perceived benefits and costs, attractive alternatives, and

social constraints and support. **Objective**: The purpose of this study was to determine the salient predictors of commitment to ATEP, and to determine differences among those students who continued, graduated, and quit ATEP. **Design**: Cross-sectional, survey. **Setting**: Surveys were completed during a course lecture at the mid-point of the fall academic semester. **Patients or Other Participants**: A total of 99 male and female athletic training students participated (n = 18, 3rd year; n = 24, 2nd year; n = 26, 1st year; and n = 31 prospective). Participants ranged in age from 18 -24 years of age (M = 20.10, SD = 1.28). Approximately one year later, 71 students were still in the major, 18 had graduated, and 10 had quit or switched majors. **Interventions**: Previously validated measures were used to assess students' perceptions of enjoyment, attractive alternatives, investments, social constraints and support, benefits and costs, and commitment to ATEP. All measures demonstrated adequate reliability for the current sample (α = .71 - .93). **Main Outcome Measures**: A simultaneous multiple regression was conducted to determine which of the SCM determinants predicted ATEP commitment. Additionally, a MANOVA was conducted to determine differences on SCM constructs between graduating, current, and discontinued students. **Results**: The multiple regression was significant: $F(5, 93) = 36.65$, $p < .001$, with 66% of the variance of ATEP commitment being accounted for by the predictors. Perceived enjoyment (β = .50) and investments (β = .26) emerged as the significant predictors, with higher perceptions of enjoyment and investments predicting higher ATEP commitment. The MANOVA was also significant: Wilks' = .75, $F(12, 182) = 2.41$, $p < .01$, with 25% of the variance being accounted for by group (graduated v. current v. quit). Post-hoc analyses revealed that students currently involved in ATEP reported significantly higher commitment and enjoyment, and lower perceived costs than students who were preparing to graduate from the ATEP. **Conclusions**: The SCM may provide a theoretical framework in which to predict ATEP students' commitment to the program, as well as behavioral commitment (e.g., stay/leave behavior). By enhancing perceptions of liking, fun, and pleasure and fostering perceived investments, ATEP programs may increase students' psychological and behavioral commitment. Future research should explore SCM constructs as a way of predicting ATEP students' graduation rates, BOC scores, and work as an ATC professional.

Health Science Reasoning Test Scores and California Critical Thinking Disposition Inventory Scores Do Not Predict Scores on the Board of Certification Examination

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Context: Grade point average (GPA) has been demonstrated as the primary predictor of success on the Board of Certification (BOC) examination for entry-level athletic trainers. This finding has not been re-examined since the BOC revised its testing format to include a broader variety of test items. Assuming that the BOC exam assesses a snapshot of critical thinking there may be other standardized assessment tools designed to measure those constructs that could predict success on the exam. **Objective:** To determine concurrent validity of the Health Science Reasoning Test (HSRT) and California Critical Thinking Disposition Inventory (CCTDI) in an athletic training student population. To determine the predictive validity of grade point average (GPA), scores on the HSRT, and scores on the CCTDI on determining BOC scores. **Design:** Cross-sectional study. **Setting:** One entry-level master's and two undergraduate athletic training education program (ATEP). **Participants:** A convenience sample of 36 athletic training students (n=16 males, n= 18 females, 2 did not indicate gender) enrolled in the final semester of three different ATEPs (n=11 from an entry-level master's ATEP in District 3, n=14 from an undergraduate ATEP in District 2, n=11 from an undergraduate ATEP in District 4) volunteered to participate in this study. Subjects were recruited by their respective program directors to participate. 24 (67%) of participants completed all aspects of the study and 23 (96%) of those passed the BOC exam on the first attempt. **Interventions:** Participants completed a basic demographic survey and provided the investigator with personal contact information in order to obtain their self-reported BOC exam scores. Program directors administered the HSRT (KR-20 = .81) and CCTDI (Cronbach's alpha = .90) concurrently to students in the spring of 2011. Participants took the BOC exam in April, June, or August, 2011. **Main Outcome Measures:** The total scores for the CCTDI and HSRT were correlated to determine the concurrent validity of administering these tests on the same day. A linear regression was used to determine the predictive validity of GPA, HSRT scores, CCTDI scores on BOC scores. **Results:** Participants scored between the 63rd and 70th percentile on the HSRT (M=21.17±3.58) and had moderate CCTDI scores (M=296.64±26.81). There was no statistically significant correlation between CCTDI and HSRT scores or between both test and BOC scores. There was a positive correlation between GPA (M= 3.47±.25) and BOC scores (M= 572.25±39.50), r=.55, p=0.005. GPA was also the only predictor of BOC scores R^2=.31, F(1,22)=9.69, p=.005. **Conclusions:** This pilot study suggests that there is no concurrent validity between the HSRT and CCTDI in athletic training students in their final semester of study. In addition, GPAappears to be the primary predictor of success on the BOC exam; however, the small sample size limits the generalizability of this finding.

Evaluation of Neuropsychological and Attentional Disturbances Following Concussion in High School Athletes

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Context: Recent research has focused on the role that computerized cognitive testing plays in the diagnosis, treatment, and decisions related to returning to physical activity following concussion 1–3. However, little investigation has been done testing the attentional deficits of high school aged athletes recovery. **Objective:** The purpose of this study is to identify differences in tracking recovery for two months after concussion with three assessments which examine different levels of cognitive function. As sport-related concussion research in the adolescent population is limited 4, this study seeks to enhance our understanding of the effect of concussion on different components of attentional function and examine their respective recovery curves. Such information would allow us to identify measures of cognitive function which sensitively reflect functional recovery and provide clinicians objective evidence to optimize timing of return-to-normal activity decisions. **Design:** Cohort study. **Setting:** Within a visually enclosed space in a laboratory, cognitive disturbances after concussion were assessed using three different computerized tests: ImPACT, Attentional Network Test (ANT), and Task Switching Test (TS). **Patients:** High school athletes who suffered a concussion in the Eugene area were identified by a certified Athletic Trainer. Each of the concussion subjects (n=12) were matched with a healthy control (n=12) and underwent examination in the following time increments: within 72 hours, one week, two weeks, one month, and two months post injury. **Main Outcome Measures:** Dependent variables were the ImPACT composite scores, the alerting, orienting, and conflict effects derived from the ANT, and the switch cost calculated from the TS. A two-way, mixed effects ANOVA was performed to determine differences between groups across time. **Results:** Concussion subjects performed significantly worse on the visual memory composite of ImPACT (mean difference=17.1; SError=4.73; P= .002) and the switch cost component of the TS (mean difference=21.77; SError =6.79; P=.004) within 72 hours of injury. Symptom score group differences were present up to one week after injury (mean difference =26.98; SError=6.93; P= .001). **Conclusions:** This investigation elucidates the inability of concussed high school athletes to effectively switch their attention between tasks initially after concussion. While symptom monitoring continues to be a tool to detect deficits, other objective measures are needed to detect subtle cognitive changes following concussion over an extended period of time post-injury. The switch cost and visual memory group differences demonstrate two measures which detect disturbances after concussion in high school athletes. Attentional testing revealed similar differences as ImPACT, but through an individualized analysis, certain subjects showed prolonged signs of impairment following concussion indicating long term deficits when analyzed on an individual basis. Therefore, the TS may prove to be an easily administered and useful clinical test sensitive to the disturbances seen after concussion in the adolescent population.

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Concussion Management Practice Patterns Amongst NCAA Division I AthleticTrainers

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Context: The 3rd International Concussion in Sport (CIS) Consensus Statement on the management of sports-related concussions was released in 2009 and included specific recommendations on the identification and management of sports related concussions. Previous reports on athletic trainers practice patterns, conducted prior to the release of the 3rd CIS, had identified a gradually increasing objective assessment protocol and more conservative management than earlier reports. **Objective**: The purpose of this study was to identify current concussion management practice patterns amongst NCAA Division I athletic trainers. **Design**: Cross sectional internet based survey. **Setting**: Population based survey. **Patients or Other Participants**: Every NCAA Division I full time athletic trainer with a publically available email address (1,895) was sent an email with a link to the survey; however 121 email addresses were invalid, leaving 1,774 potential participants. There were 610 responses (34.4% response rate). The respondents average athletic training experience was 11.7 $\pm$ 8.7 years, most (89%, 544/610) has earned a master's degree, reported a mean of 2.9 $\pm$ 3.3 concussion related CEUs in the previous three years and evaluated a mean of 5.3 $\pm$ 3.7 concussions per year. **Interventions**: The 58-item survey was reviewed for face validity by content experts and reliability was established, using Cronbach's alpha, with a pilot assessment of 10 certified athletic trainers. **Main Outcome Measures**: Dependent variables of interest included the descriptive statistics of common concussion

assessment techniques. Respondents were classified as employing a multifaceted approach if they utilized as least two objective assessment techniques. **Results**: The majority of respondents (87.2%; 532/610) utilized a multifaceted initial assessment and most (74.8%; 456/610) utilized at least three objective techniques when evaluating a potential concussion. The most commonly utilized tool was a symptom checklist (93.6%; 483/516) followed by cognitive assessment (90.7%), balance testing (86.3%) and the least commonly utilized objective tool was neuropsychological testing (79.5%; 419/527). Few respondents (36%; 187/520) utilized concussion grading scales. To determine when an individual is cleared to return to participation, the majority of respondents (77%; 470/610) reported utilizing a multi-faceted approach. The most common return-to-participation objective assessments included symptom checklists (90.3%; 439/486), neuropsychological testing (73.8%; 361/489), balance testing (67.4%; 341/507), and cognitive testing (58.8%; 294/500). Finally, the majority of respondents reported performing baseline testing, on at least one occasion, of neuropsychological testing (90%; 371/412), balance testing (74.0%; 370/500), and cognitive testing (72.2%; 285/395). **Conclusion**: The results of this study indicate the majority of NCAA Division I athletic trainers utilize a multi-faceted approach to both acute concussion assessment and determining return-to-participation status and also conduct extensive baseline testing. Finally, these findings show a continued increase in the rate of athletic trainers utilizing objective assessments and multi-faceted approaches to concussion management over the last decade.

Concussion Assessment and Management Techniques Employed by Athletic Trainers

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Context: Understanding the practices currently employed by athletic trainers (ATs) will allow clinicians to identify potential strategies for enhancing the quality of care provided to patients. **Objective:** To assess current clinical concussion diagnostic and return-to-participation practices among ATs working in a variety of settings and with different patient populations. **Design:** Cross-sectional. **Setting:** Each participant electronically completed the online survey at a preferred location. **Patients or Other Participants:** A link to the survey was randomly sent via email to a convenience sample of3,222NATA members. One thousand fifty-three certified ATs (32.7%) responded to the survey (11.2±9.1 years AT experience) with the majority of our respondents working in high schools (39.0%) and sports medicine clinics (14.1%). **Interventions:** Prospective participants received electronic correspondence informing them of the study purpose and provided a link to the online survey instrument. A reminder email was sent approximately 6 weeks later, and the survey remained online for a total of8 weeks. **Main Outcome Measure(s):** Survey questions addressed athletic training experience and primary patient populations (e.g. sports) served. We collected information on the annual number of concussions evaluated and tools employed to diagnose, manage, and safely return an athlete to participation. We surveyed participants on their familiarization and use of current research and recommendations in informing their concussion management protocols Descriptive statistics were computed for each variable. **Results:** Participants reported observing 10.8±11.0 concussions per year, with the majority occurring in football (27.1%). Clinical examination (70.6%) was the most commonly reported means for evaluating and diagnosing concussion. Less than half of our respondents employ the Standardized Assessment of Concussion (44.4%), any variation of the Romberg test (43.8%), and computerized neuropsychological testing (43.6%). Clinical examination (73.4%), return-to-participation guidelines (67.7%), physician recommendation(62.7%), and player symptom self-report (42.5%) contributed to ATs' return-to-participation decisions. Only 21% of ATs reported using all 3 recommended domains of the concussion battery (symptom checklist, neuropsychological assessment, and postural stability test).Fifty-three percent reported using at least 2 methods, 75% reported using at least one 1 method, and 25% did not report using any methods. **Conclusions:** Our study demonstrated a growth in the number of ATs incorporating objective clinical measures of concussion as a part of their concussion management protocols compared to previous research. The number of ATs reporting the use of neuropsychological testing in managing concussions has increased threefold. Conversely, fewer ATs reported using a standard clinical examination in their concussion assessment. These findings suggest that while an increasing body of sport-related concussion research exists, ATs must continue to improve upon their use of both objective concussion assessment tools and the standard clinical examination.

Gender Differences in Concussion Reporting Prevalence Across Games and Practices Among a Sample of High School Athletes

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Purpose: Gender differences concerning concussion outcomes have been debated. While some studies have shown a higher rate of concussions in females, there is little empirical evidence whether concussion reporting differs between gender and across different environmental contexts. **Objective:** To examine the influence of gender on concussion reporting across games and practices in a sample of high school athletes. **Design:** A cross-sectional survey design. **Setting:** The pre-validated survey instrument was completed at the athletes' homes. **Patients or Other Participants:** A convenience sample of 162 high school athletes (98 males, 64 females; age=15.7±1.4) completed the survey. **Interventions:** Athletes attended a school-based meeting and received a packet containing the pre-validated survey and consent documents to take home, complete, and return via mail. The criterion variable was gender (male/female). **Main Outcome Measures:** Self-report concussion reporting history was used to obtain all outcome measures. C*oncussion reporting* was defined as indicating reporting a recalled concussion or "bell ringer" to a coach or medical professional. Concussion reporting measures included: 1) proportion of concussions and "bell ringers" reported during practices; 2) proportion of concussions and "bell ringers" reported during games; 3) proportion of athletes who disclosed continuing to participate in a game while symptomatic from a possible concussion; and 4) proportion of athletes who disclosed continuing to participate in a practice while symptomatic from a possible concussion. Binomial regression models [Prevalence Ratios (PR) and 95% Confidence Intervals (CI)] were used to analyze the influence of gender (males vs. females) on the concussion reporting measures. **Results**: Only 40% of *concussion* events and 13% of *bell ringer* events in the sample were reportedly disclosed following possible concussive injury as described in a previous study. Males (41.1%, 39/95) were more likely to report continuing in a game while symptomatic (PR=1.98, 95% CI: 1.15, 3.41) than females (20.6%, 13/63). Males (27.9%, 26/93) and females (22.6%, 14.62) were equally likely to continue to participate in a practice while symptomatic (PR=1.24, 95% CI: 0.70, 2.18). A trend towards males (24.2%, 67/277) being more likely to report in games than females (14.3%, 6/42) was observed (PR=1.69, 95% CI: 0.78, 3.66). However, in practices the trend was reversed with males (10.7%, 31/289) being less likely to report (PR=0.61, 95% CI: 0.31, 1.19) than females (17.7%, 9/51). **Conclusions:** Context (practice vs. game) may affect concussion-reporting decisions of males and females differently. Clinicians should be aware of these contextual differences in reporting and educate coaches and athletes about the importance of reporting potential concussive events, regardless of the context. Efforts should be directed towards making both practice and game settings, environments in which athletes feel comfortable about reporting their injuries.

Validation of Physical Activity as a Functional Outcome Measure Following a Concussion

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Context: Diagnosis and management of concussions rely heavily on impairment (cognitive, neurologic, equilibrium) and the presence of symptoms, with little emphasis placed on function. The World Health Organization defines function as a person's movement within their environment. A person's movement is also considered physical activity which can be measured using a small, objective accelerometer. Physical activity (PA) and step counts (SC) may be useful measurement tools for assessing function. **Objective:** To validate the use of an accelerometer's PA and SC as functional outcome measures following a concussion. Design: Observational matched-pair. **Setting:** Clinical athletic training community under free-living conditions. **Patients or Other Participants:** Twenty-three adult participants (n=23; n=14 concussed, n=9 matched control; age: mean ± SD, 19.65±1.1yrs) volunteered for this study. The healthy controls were matched for age, sex, athletic position, perceived physical activity level, and area of academic study. **Interventions:** Participants wore an Actigraph GT3X+ accelerometer on right hip either after sustaining a concussion or being identified as a healthy control for over a week (Concussed: 9.29±2.6days, Control: 7.89±1.6days). Acceler-ometers have been shown to be reliable and validated in various patient populations. **Main Outcome Measures:** Dependent variables were mean PA and SC for symptomatic days, for asymptomatic days and for controls. Within the concussion group, differences in PA and SC for symptomatic days and asymptomatic days were evaluated using paired t-test. Differences in PA

and SC for the concussed group and healthy controls were evaluated for symptomatic days and asymptomatic days using an independent t-test. Significance was set a priori at alpha level <0.05 with Bonferroni adjustment. **Results:** There was a significant difference in PA counts between symptomatic and asymptomatic (t_{13} = -2.369; P<0.05), but not for SC (t_{13} = -1.826; P>0.05). Concussed participants while symptomatic had a mean PA count of 285366.9 ±113213 and a mean SC of 8175.43 ±3476.1. Once asymptomatic, mean PA counts increased to 352827.4 ±90979 and mean SC increased to 9721±3380. There was a significant difference in PA counts between symptomatic concussed and healthy controls (t_{21} = -2.092; P< 0.05), but not for SC (t_{21} = -1.192; P>0.05). There was no difference between asymptomatic concussed and healthy controls in PA counts (t_{21}= -0.717; P>0.05) or SC (t_{21}= -0.079; P>0.05). Mean PA and SC for healthy controls were similar to asymptomatic concussed with a mean PA count of 381496.9±97646 and SC of 9828.78 ±2837. **Conclusions:** The results provide evidence for the use of PA counts as a functional outcome measure during concussion recovery. PA counts of the concussed group, once asymptomatic, reflect values that mimic healthy controls, concluding that an increase in PA counts in conjunction with symptom and cognitive based tools can assist athletic trainers with return to play decisions following a concussion.

Changes in Means and Factor Structure of Multidimensional Fatigue Following Sport-Related Concussion

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Context: Fatigue is a common, long-term symptom of sport-related concussions. Yet, little is known about changes in fatigue following injury. **Objective:** To assess changes in fatigue-specific health-related quality of life (HRQOL), as measured by the Pediatric Quality of Life Inventory (PedsQL) Multidimensional Fatigue Scale (MFS), in concussed high school athletes from baseline to 10 days post-concussion. **Design:** Cohort. **Setting:** High school athletic training facilities. **Patients or Other Participants:** A convenience sample of 100adolescent athletes (84 males, 16females,age=15.5±1.9; grade= 9.1±.94)who suffered a sport-related concussion that was diagnosed by an athletic trainer. **Interventions:** The independent variable was time. Participants completed the MFS during a single-session at pre-season baseline (BL) and two time points following concussion: Day 3 (D3) and Day 10 (D10). The MFS is a valid and reliable measure of fatigue-specific HRQOL in pediatric patients and includes three subscales: General Fatigue (General), Sleep/Rest Fatigue (Sleep) and Cognitive Fatigue (Cognitive). Lower subscale scores indicating lower fatigue-specific HRQOL. **Main Outcome Measures:** The dependent variables were the three MFS subscale scores at BL, D3 and D10.Generalized estimating equations based on an inverse Gaussian distribution, autocorrelation structure and robust estimators were used to assess change over time. Bonferroni comparisons evaluated pairwise differences (p<.05, two-tailed). Confirmatory factor analysis (CFA) based on an asymptotically distribution free model estimated changes in the factor structure over time. **Results:** Mean values (±SD) for General dropped significantly from BL (84.1±15.3) to D3 post-concussion (73.0±23.4), as did Cognitive (82.6±17.9 to 71.6±23,4); both p<0.001. Sleep did not change (70.0±18.5 to 70.6±23.0) during this period. By D10, all scores had increased significantly (p<0.05) above BL: General (90.7±14.9), Cognitive (87±17.3) and Sleep (88.2±13.9).The CFA model fit the data well (X^2 = 32.5 (21), p=0.052, GFI=.95, RMSEA =.074). The average factor loading at BL was .67,at D3,.86 and at D10, .78. The General (r=.54),Sleep (r=.57) and Cognitive (r=.41) scales were substantially correlated across D3 and D10. Modifications indices identified moderate correlations for Cognition from BL to D3 (r=.46) and BL to D10 (r=.53) (all, p<0.001).The correlational structure of fatigue changed over time. All factor loadings at D3 were significantly different from those at BL (p<0.001). At D10, factor loadings for Sleep and Cognitive remained different from BL (p<0.01).**Conclusions**: General and Cognitive subscale scores fell substantially following post-concussive injury, but increased significantly above BL by D10. The CFA strongly supported the validity of the MFS in high school athletes. The correlational structure of the MFS changed over time, indicating that the three scales should be interpreted independently. All mean scale scores increased from D3 to D10, but General and Sleep deficits persisted from D3 to D10. Cognitive deficits persisted across all measurement periods. Funded by a grant from the National Operating Committee on Standards for Athletic Equipment (NOCSAE).

Prevalence of Functional Ankle Instability in a College Age Population

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Context: Functional Ankle Instability (FAI) is a condition that often occurs following a lateral ankle sprain. FAI is typically determined through a self-reported feeling of instability during activities of daily life or athletic participation. While numerous authors report the frequent occurrence of this condition, limited work has been done identifying the prevalence of FAI. **Objective**: To determine the prevalence of FAI in a college age population. **Design:** Cross Sectional Study **Setting:** Classroom setting **Patients or Other Participants:** We recruited 1,788 subjects (847 males, 914 females, 19.5±1.8 years) to participate in this study. Participants had to be enrolled in the local university and have no history of lower leg fractures to volunteer for the study. **Interventions:** All subjects completed the Identification of Functional Ankle Instability (IdFAI) questionnaire on one occasion. The IdFAI is a 10 item questionnaire that was specifically developed to identify people with FAI. Scores on the IdFAI range from 0 to 37. A score of 11 or higher on the IdFAI indicates the participant has FAI. Test-retest reliability of the IdFAI is excellent ($ICC_{2,1}$=0.92, SEM=2.21). Frequencies were used to determine prevalence of FAI. Means and standard deviations were also calculated on the IdFAI score. A Chi-square test of independence was calculated comparing the frequency of FAI in men and women. **Main Outcome Measures:** Dependent variables were: presence or absence of FAI, history of a lateral ankle sprain, score of the IdFAI, and gender. **Results:** In this sample, 799 participants (45%) were identified as having FAI and the remaining 989 (55%) did not have FAI. Participants who were identified as having FAI had an average score of 16.5 (SD = 4.8) on the IdFAI and subjects who were identified as not having FAI had an average score of 4.2 (SD= 3.6). Additionally, 1006 (56%) of the participants had a history of a lateral ankle sprain. Of the participates with a history of a lateral ankle sprain, 678 (67%) were identified as having FAI, while the other 328 (33%) were not identified as having FAI. Chi-square test of independence yielded no significant relationship between gender and presence of FAI ($\chi^2(1)$ = .08, p=.78). Specifically, 45% (n=379 of the 847) of the men had FAI and 44% (n= 403 of the 914) of the women had FAI. **Conclusions:** FAI is a relatively common pathology affecting approximately 45% of the sample population. Of the participants who had a history of a lateral ankle sprain, approximately two-thirds of them went on to have FAI. Finally, FAI seems to affect men and women equally.

Description of Youth Soccer Coaches' Attitudes and Beliefs Regarding ACL Injury Prevention Programming and Program Compliance.

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Context: Anterior Cruciate Ligament (ACL) injury prevention programs (ACL IPP) are effective at decreasing injury risk in youth soccer players. However, the efficacy of an ACL IPP is dependent on successful compliance in the target population. In youth soccer, the coach is primarily responsible for implementing an ACL IPP. Thus, understanding factors that influence youth soccer coaches' compliance with an ACL IPP may be important for successful implementation and efficacy of ACL IPP. **Objective:** 1) Describe youth soccer coaches' attitudes and beliefs toward ACL IPP. 2) Describe youth soccer coaches' compliance with an ACL IPP after attending an educational workshop and receipt of supplemental instructional materials. **Design:** Cross-sectional. **Setting:** Soccer complex. **Patients or Other Participants:** A convenient sample of 39 soccer coaches (age: 34.67±9.57 yrs.) of elite-level youth soccer club teams. **Interventions:** Youth soccer coaches were administered a 25-item survey evaluating their attitudes and beliefs toward ACL IPP after a 45-minute educational meeting on the importance of ACL IPP and specific ACL IPP exercises to perform. Coaches were also provided with additional resources for implementing an ACL IPP (exercise manuals, coaching cue cards, and videos). Compliance with the ACL IPP was monitored 3-weeks later. **Main Outcome Measures:** Survey questions were categorized into 4 domains of attitudes and beliefs toward ACL IPP: (1) time devotion, (2) comfort level implementing ACL IPP, (3) likelihood of implementing ACL IPP, (4) perceived effectiveness of ACL IPP. Responses were scored based on a 5-point Likert scale (1-strongly disagree to 5-strongly agree). Compliance was assessed as a dichotomous outcome completion/no completion) and expressed as a percentage of teams performing the ACL IPP. Descriptive statistics were computed for each variable to determine coaches' attitudes, beliefs, and compliance regarding an ACL IPP. **Results:** 92.1% of coaches agreed or strongly agreed to devote 15 minutes to an ACL IPP during practice (agreement =4.47 ±0.73). 97.3% of coaches agreed or strongly agreed to being comfortable implementing an ACL IPP if given instruction (agreement =4.50±0.56). 84.6% of

coaches agreed or strongly agreed to implement a daily ACL IPP in the upcoming season (agreement =4.37±0.71). 79.5% of coaches agreed or strongly agreed that an ACL IPP would reduce injury (agreement =4.05±0.66). Compliance with the ACL IPP was 53% at the 3-week follow-up period. **Conclusions:** Soccer coaches are generally agreeable to implementing an ACL IPP, and believe these programs can reduce injury risk. However, coaches' attitudes and beliefs do not appear to directly translate to ACL IPP implementation, as only 53% teams had adopted the ACL IPP after 3-weeks. Future research identifying factors to increase coaches' ACL IPP compliance is warranted. Funding provided by the Injury Prevention Research Center at the University of North Carolina at Chapel Hill and the National Academy of Sports Medicine

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Baseline Factors Associated with Incident Lower Extremity Injury during Cadet Basic Training among Military Academy Cadets: the JUMP-ACL Study

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Context: Characterizing the relationship between baseline injury history and subsequent injury among physically-active collegiate-age youth may provide important information to guide injury preventive measures. Military academies provide access to large numbers of physically-active collegiate-age youth. **Objective**: To determine the association between the baseline factors and incident lower extremity injury (LE) during Cadet Basic Training (typically July 1 to August 31) among first year military academy cadets. **Design**: The JUMP-ACL Study: A collaborative multi-site prospective cohort study. Baseline JUMP-ACL survey data linked to incident lower extremity injuries ascertained via the Defense Medical Surveillance System (DMSS). DMSS records all clinic visits of a medical nature. **Setting**: The three largest U.S. military academies. **Participants**: First year cadets (n=9,811) enrolled 2005 to 2008 in JUMP-ACL. **Interventions**: Self-reported prior injuries to the lower extremity or lower leg in the past 6 months. Additionally, the following specific injuries: ankle sprain, shin splints, lower limb stress fracture, hip injury, and knee sprain. **Main Outcomes Measures**: Medically treated injuries of the lower extremity during Cadet Basic Training, obtained from the DMSS injury surveillance system. Acute injuries (ICD-9 codes in the 800-900s) included: fracture, dislocations, and sprains/strains. Injury-related musculoskeletal injuries (ICD-9 codes in the 700s) included: inflammation and pain (overuse), joint derangement, stress fracture, sprain/strain/rupture, or dislocation. To minimize duplicate counting from multiple medical encounters per event, encounters for the same three-digit ICD-9 code within 60 days of the first encounter were excluded. Risk ratios and 95% confidence intervals were calculated with multivariate general log-binomial regression models adjusted for gender, age, prep academy attendance, academy, and previous injury history. **Results**: During Basic Cadet Training (July and August), there were a total of 1,438 medically treated acute LE injuries and 1,719 LE musculoskeletal-related injury conditions. The most frequent types of acute injuries was ankle and lower leg sprains/strains (38.7%) and unspecified lower extremity sprains/strains (34.9%). Overuse injuries were the most frequent types of musculoskeletal-related conditions (89.6%). The overall risk of incident medically treated LE injury during basic training was 23.2% (95% CI: 22.3%, 24.0%). Injury risk was greater for females (39.1%) compared to males (18.0%) for all LE injuries and specific injuries. Cadets with a previous history of LE or lower leg injury were at increased risk for a medically treated LE injury (risk ratio [RR]=1.71, 95% CI: 1.57, 1.86) and lower leg injury (RR=1.57, 95% CI: 1.45, 1.71), respectively. Stronger associations were observed for specific injuries including the ankle (RR=2.79, 95% CI: 2.44, 3.19). **Conclusions**: Injury history upon entry into the academy is strongly associated with medically-treated LE injuries during Cadet Basic Training. These results provide a baseline activity and injury profile for first year military cadets that academy health care providers can use to target prevention efforts.

Psychosocial Rehabilitation Experiences of the ACL Reconstructed Athlete

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Context: The majority of research on the rehabilitation process, for the ACL reconstructed athlete, has focused on physical rehabilitation. There is very little research on the psychosocial aspect of the ACL reconstructed athlete's rehabilitation experience. **Objective:** To explore the ACL reconstructed athlete's psychosocial rehabilitation experiences. Further, to discover the psychosocial support mechanisms utilized during the rehabilitation process. **Design:** Descriptive qualitative method of inquiry with a grounded theory approach. **Setting:** Structured personal interviews were conducted with NCAA Division I collegiate athletes in the Midwest. **Patients or Other Participants:**9 NCAA Division I athletes (5 males, 4 females; 19.33 ± 1.035 years old),attending 4 different institutions in the Midwest who have completed their rehabilitation for an ACL reconstructed knee were interviewed. **Data Collection and Analysis:** Data was collected via recorded personal interviews. Data was

analyzed through the constant comparative method of grounded theory. Data triangulation, member checking, and peer-review strategies were used to ensure trustworthiness of the data. **Results:** Athletes reported that their relationship with their AT was the most important psychosocial support mechanism during the rehabilitation process. Athletes viewed their AT as a psychologically stabilizing force. The ATs ability to encourage, reassure and relate to the rehabilitation process was paramount. In addition to the AT support, the athletes reported that support from the coaching staff was also an important psychosocial support mechanism. One participant reported that the lack of psychosocial support from the coaching staff was psychologically detrimental to her rehabilitation experience. These psychosocial support mechanisms were crucial in helping the athlete to deal with the psychological aspect of their rehabilitation experience. **Conclusions:** My findings are consistent with the psychosocial literature that illustrates the crucial role ATs/coaches play as a psychosocial support during the rehabilitation process and the importance of this relationship to athlete/patient. Future researchers should take a closer look at the perceptions of NCAA Division I coaches' role in the psychosocial support of the athlete during the rehabilitation process.

Qualitative Analysis of Injuries in Stock Car Racing

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Context: Athletic trainers work with athletes in variety of sports. Despite being a popular sport, little is known about the injuries that occur during stock car racing. **Objective**: To examine the injuries of short track stock car drivers. **Design**: Grounded theory. **Setting**: University exercise science laboratory, stock car racing shop facility, and team pits at various race tracks. **Patients or Other Participants**: Forty short track stock car drivers (age = 35.91 ± 13.4 years; height 178.51 ± 7.39 cm; weight 86.20 ± 16.67 kg; racing experience = 13.58 ± 11.30 years; age at start of their racing career = 21.39 ± 9.53 years) participated in this study. The sample population included drivers from 27 different states in the United States of America who raced in several different racing classes on dirt and/or asphalt tracks. Criterion sampling was used during an internet search to compile a list of drivers that competed in either dirt or asphalt short track stock car racing. Drivers were then randomly selected and their participation was elicited via email. The number of participants in this study was guided by data saturation. **Data Collection and Analysis**: Participants completed either telephone or in-person interviews averaging 48.0 ± 9.0 minutes. The interview included questions from the Stock Car Driver Survey which included open ended questions, fixed choice, and 10 point Likert scale items. Questions were asked in several categories including racing related injuries, medical attention required, ongoing physical problems, future injury concerns, and injury prevention. The answers to open ended questions were transcribed verbatim and analyzed using inductive content analysis. **Results**: Subjects identified a variety of racing injuries organized according to higher order themes with the most common falling into the categories of "back/torso," "upper body," and "head" related injuries. Various injuries included "back pain due to jolts", "ruptured tendon from the steering wheel", and "concussions." The majority of subjects who required medical attention for injuries either received emergency medical service help at the race track for injuries such as "concussions", "ACL injuries", and "dislocated shoulders", or were hospitalized. The most common ongoing injuries were identified as "back pain", "neck pain", and "wrist and hand problems". The vast majority of drivers identified their biggest concerns for future injuries as "fire/burns" or "head and neck injuries." Drivers identified wearing proper racing attire, head and neck restraints, and "safer barriers" as some ways to prevent stock car racing injuries. A variety of other data were obtained. **Conclusions**: Understanding the different types of injuries that stock car drivers face can help the athletic trainer understand the needs of these athletes. This information will allow athletic trainers to correctly evaluate and treat potential injuries of the participants in this rapidly growing sport.

Use of Head and Neck Injury Prevention Devices in Stock Car Racing

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Context: Head and neck (HAN) injuries are somewhat common and sometimes lethal in stock car racing. A variety of devices have been designed with the goal of preventing injuries and death. **Objective:** This study assessed stock car drivers concerns about, and use of, head and neck injury prevention devices (HANIPD).**Design:** Cross-sectional survey. **Setting:** Population based. **Patients or Other Participants:** Fifty one stock car drivers (age =34.51±11.67 years; racing experience=11.78±8.16 years) served as participants. The sample included drivers from 14 different states in the USA who raced in a variety of classes. Criterion sampling was used during an internet search to compile a list of drivers, who were then randomly selected. The number of participants in this study was guided by data saturation. **Interventions:** Data were collected through an online Survey of the Use of Head and Neck Restraint Devices in Stock Car Racing. **Main Outcome Measures:** Quantitative data were analyzed using a Pearson's correlation coefficient to assess the relationships between the driver's

Likert scale ratings of their concern about HAN injuries, the importance of using a HANIPD, how often they wear a HANIPD, and the cost of their stock car. Qualitative data, such as the driver's response to open ended questions regarding use and type of HANIPD, injury occurrence, and HANIPD likes and dislikes were analyzed using inductive content analysis. **Results:** Significant ($p \leq 0.01$) correlations were found between concern about HAN injuries and how important it is to use a HANIPD (R=0.79) and how often the drivers used a HANIPD(R=0.47), as well as between how important it is to use the HANIPD and how often they wore the device (R=0.61). No correlation was found ($p > 0.05$) between the cost of their stock car and any variable. Results of qualitative analysis revealed the main reason the drivers used the HANIPD was concern over injury or death. While most drivers did not have injuries, several attributed their safety to the HANIPD. For drivers who experienced injuries, most had neck or back injuries including pulled or sore neck muscles, ligament problems, and whiplash. Cost was the main reason for not using a HANIPD. Other dislikes about the HANIPD included limited vision due to restricted head movement, difficulty putting it on and taking it off, and discomfort. A variety of other data were gathered. **Conclusions:** Athletic trainers are uniquely qualified to serve this population of athletes and thus should be knowledgeable about HANIPD, help identify the pros and cons of HANIPD, educate drivers about the role these devices play in injury prevention, and serve in the role of treating head and neck injuries when they occur.

Comparison of Hamstring Strain Incidence and Injury Patterns Between Male and Female Intercollegiate Soccer Athletes

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Context: Hamstring strains have high prevalence and recurrence rates among soccer players, and male soccer players have a higher incidence rate of hamstring strains than female players. Currently, no data exists that compares the incidence rates at different times of soccer participation or describes the injury event patterns separately for first-time and recurrent hamstring strains between males and females. **Objective:** To compare the hamstring strain incidence between sexes during different event types and times of season and to describe and compare the injury event patterns of first-time and recurrent hamstring strains between male and female college soccer athletes. **Design:** Descriptive epidemiology study. **Setting:** Field research of NCAA men's and women's soccer teams. **Patients or Other Participants:** The participants were collegiate soccer athletes who incurred a hamstring strain that was recorded in the NCAA Injury Surveillance System between 2004-2009.(males: first-time= 242, recurrent=67; females: first-time= 176,recurrent=24). **Main Outcome Measures:** Incidence rate ratios (IRRs) compared the incidence of hamstring strains between the sexes in total and during competitions, practices, the preseason and the in season. To examine differences in injury events factors between male and female soccer players, Chi-Square tests were used to compare the national estimated frequencies of hamstring strains that occurred within levels of the following variables: season (preseason, in season, postseason), practice segment (warmup, individual drills, team drills, conditioning), time of game (warmup/first half, second half/overtime), event type (game, practice), field location (offense, defense), player position (forward, midfield, defender), injury mechanism, and soccer activity (shooting/passing, defending, running, ball handling).**Results:** Males were 64% more likely than females to sustain a hamstring strain.(IRR=1.64; 95% CI: 1.37-1.96). Men had significantly higher rates of hamstring strains than women during competitions (IRR= 2.42;95%CI: 1.82-3.23), practices (IRR= 1.34; 95%CI:1.06-1.68), and the inseason (IRR=1.98;95%CI: 1.56-2.52). There was no significant difference in hamstring strain incidence during the preseason (IRR=1.04; 95%CI: 0.79-1.37).Males had a significantly higher proportion of recurrent hamstring strains compared to females (M=22%, F=12%, p=0.003). There were no significant differences in the distribution of strains within the injury event factors between the sexes for first-time or recurrent hamstring strains. **Conclusions:** Males, compared to females, were more likely to sustain a hamstring strain during games, practices and the inseason. Also, males had a higher frequency of recurrent hamstring strains. While there were no significant differences in the hamstring strain event factors between sexes for first-time or recurrent injuries, common patterns emerged to describe all hamstring strains. These findings provide evidence to assist in the development of preventive and rehabilitative exercise programs as well as further research on hamstring strains.

The Incidence of Injury Among Male and Female Intercollegiate Rugby Players

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Context: The NCAA currently classifies women's rugby as an emerging sport. However, very few studies have examined injury rates in women's collegiate rugby and even less have compared injury rates between female and male American players. **Objective:** The purpose of this study was to compare injury rates between female and male intercollegiate club rugby players at a United States Service Academy. **Design:** Injury surveillance data were collected and reviewed over five academic years from August 2006 through June 2011. All athletes received their care through a closed healthcare system and all injuries requiring medical attention were documented in an injury surveillance database. As a result, nearly all injuries experienced by rugby players during the study period were documented. Injury was defined as an event occurring during rugby training or competition which required attention from a medical provider. The Academy requires strict adherence to accountability; therefore, exposure data was available through roster and attendance records for all rugby participants during the study period. **Setting:** US Service Academy. **Participants:** Participants were college rugby players. There were 129 females and 240 males that participated during the five year study period. **Main Outcome Measures:** The primary outcome of interest was the incidence rate (IR) of injury during the study period per 1000 player-days. We calculated rate ratios (RR) using a poison distribution to compare the rates by sex. **Results:** During the study period there were 200 injuries documented among females (IR=2.91) and 459 injuries among males (IR=3.77). The overall incidence rate for injury was 30% higher (95% CI: 1.09, 1.54) among men when compared to women; however, the distribution of injuries varied by sex. The incidence rate for ACL injury among female rugby players was 5.3 times (95% CI: 1.33, 30.53) higher when compared to males. In contrast, males were 2.5 times (95% CI: 2.41, 2.67) more likely to sustain a fracture than females. The rate of acromio-clavicular joint injury was also 2.2 times (95% CI: 1.03, 5.19) higher among males when compared to females. While the rates of concussion were similar between males and females, males were 5.3 times (95% CI: 2.22, 17.79) more likely to sustain a facial injury, 2.5 (95% CI: 0.92, 8.39) times more likely to experience an eye injury, and11.3 times (95% CI: 10.74, 11.87) more likely to sustain a head injury other than concussion. Finally, males were 6.5 times (95% CI: 2.65, 20.91) more likely to have an open wound than females. **Conclusions:** The results of this study illustrate some key differences in injury patterns between female and male American rugby players. These differences may reflect distinct playing styles which could be the result of the American football backgrounds which are common among many male players.

Post-Traumatic Ankle Osteoarthritis Influences Stair Ascent & Descent Kinetics

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Context: Post-traumatic ankle osteoarthritis (PTAO) is a condition characterized by pain and disability and is often the result of a ligamentous injury or fracture to the ankle joint complex. Research has consistently identified significant increases in clinical disablement but only recently begun to systematically quantify sensorimotor dysfunction in this population. To date, those with PTAO have been shown to have a number of sensorimotor impairments. However, no investigation has quantified how PTAO affects sensorimotor function during activities that are not completed over level ground. **Objective:** To determine if PTAO influences the kinetic patterns of stair ascent and descent relative to age matched controls. **Design:** Case-control. **Setting:** Controlled, research laboratory. **Participants:** Nine subjects with unilateral PTAO (age: 51.8±10.5 years, height: 171.9±9.9cm, weight: 75.2±16.3 kg) and eight age- matched controls (age: 52.8±11.9 years, height: 172.1± 11.3cm, weight: 83.6± 23.4 kg) volunteered to participate. **Interventions:** Each subject com-pleted a total of 5 ascents and 5 descents on a custom built stair case that housed an embedded force plate within the second step. All trials were conducted so that the PTAO subjects struck the force plate with their involved limb while the controls subjects struck the force plate with their matched limb which was based on limb dominance. **Main Outcome Measures:** Raw and normalized, relative to body weight, vertical ground reaction forces (vGRF) were recorded at three points during the gait cycle. Specifically, the peak vGRF was recorded during weight acceptance (F1) and during terminal stance (F2). Similarly, the unloading force during midstance (Fmin) was also recorded. Both the raw and normalized vGRF outcomes were then submitted to independent sample t-tests to determine group differences. **Results:** Demographic characteristics did not differ between the groups ($p>0.05$). During stair ascent, significantly higher raw F1 vGRF (PTOA: 707±105N, Control: 518±114N), raw F2 vGRF (PTOA: 718±81N, Control: 599±111N), and normalized F1 VGRF (PTOA: 1.03±0.28%, Control: 0.65±0.28%) were observed in those with PTAO ($p\leq0.03$). Similarly, a statistical trend ($p=0.07$) was observed for normalized F2 vGRF in those with PTAO (PTOA: 1.05±0.27%, Control: 0.76±0.29%). No group differences were observed raw or normalized Fmin during stair ascent ($P>0.05$). During stair descent, significantly higher raw F1 vGRF (PTOA: 912±163N, Control: 666± 225N) and normalized F1 vGRF (PTOA: 1.37±0.38%, Control: 0.67± 0.25%) were observed in those with PTAO ($p\leq0.02$). No group differences were observed raw or normalized F2 or Fmin during stair descent ($P>0.05$). **Conclusions**: The results suggest that those with PTAO use different kinetic patterns to ascend and descend stairs. Specifically, these kinetic patterns suggest that those with PTAO have a reduced ability to attenuate weight acceptance while navigating stairs. Further, these findings are consistent with previously identified sensorimotor impairments during level ground ambulation in this population.

The Relationship between Intensity of Physical Activity and Knee Osteoarthritis Development

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Context: Knee osteoarthritis (OA) is known to progressively worsen with aging. Previous research has reported physical activity across the lifespan may have a protective effect on knee joint degeneration. Currently, the amount or intensity of physical activity and its relationship with knee OA is unknown. **Objective:** To determine if there is a relationship between intensity of physical activity and knee OA development. **Design:** Prospective randomized control clinical trial. **Setting:** Controlled, research laboratory. **Participants:** Thirty C57Bl/6J mice were monitored beginning at three months of age until the end of their lifespan. **Interventions:** Mice were randomly allocated to a cage with a running wheel (RUN group, fifteen mice (eight male and seven female)) or no running wheel (control, fifteen mice (seven male and eight female)). Wheel running activity was measured with a magnetic sensor and digital odometer and has been reported as a reliable and valid measure of physical activity in mice. Daily distance and duration were measured and average running speed was calculated for each week of the entire lifespan. A diagnostic ultrasound (SONOS 5500 Ultrasound and 15-6L ultrasound probe) was used to measure medial and lateral knee joint space in both hind limbs every month. **Main Outcome Measures:** Medial and lateral knee joint space (cm) in both hindlimbs were measured as a marker for the development of OA on all 30 mice every 4 weeks of their lifespan. Each mouse was anesthetized with isoflurane gas. The mouse was then shaved and ultrasound gel was

applied to the medial and lateral aspect of both hindlimbs. Diagnostic ultrasound (SONOS 5500, Agilent Technologies, Andover MD) with a SONOS 15-6_L ultrasound probe was utilized to image both hindlimbs. Distance, duration, and speed were recorded every week in the RUN group. **Results:** Across the lifespan, there were no significant relationships between distance (p = .084), duration (p = .511), and speed (p = .125) with hindlimb joint space. Daily distance averaged 2.74 km/day ±1.92, duration average 109.9 min day± 72.6 and speed averaged 23.75 m/min ± 6.20 across the lifespan. Right medial joint space averaged .19mm± .04, left medial averaged .19mm ± .03, right lateral averaged .19mm ± .04, left lateral averaged .18mm ± .04 across the lifespan. **Conclusions**: This strain of mice is genetically identical and may account for the lack of a significant relationship. C57Bl/6J mice are known to be moderately active. Other strains of mice are known to have significantly higher and lower levels of activity. Comparing different strains of mice (low active, high active) and knee OA development may give a better indication of the impact of intensity of physical activity.

Normative Values for a Young Athletic Population on the KOOS and WOMAC: History of Knee Ligament Injury is Associated with Lower Scores

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Context: The use of patient reported outcome measures to assess clinical outcomes following injury and surgery have become common in treating young athletes with orthopaedic injuries; however, normative data for these measures is limited and often includes a wide range of ages and activity levels. **Objective:** The purpose of this study was to provide normative data for the KOOS and WOMAC in a young and athletic population, and to compare scores between subjects with a history of knee ligament injury and those with no prior history. **Design:** Cross Sectional. **Setting:** US Service Academy. **Participants:**1177 college freshman entering a US Service Academy in June 2011. **Methods:** All subjects were healthy and had been medically screened to meet the physical induction standards for military service. The outcome measures of interest were administered within the first week of arriving at the Academy. A prior history of knee ligament injury was docu-mented at the time of administration. We calculated mean scale scores along with standard deviations for the KOOS and WOMAC among those with no prior history of knee joint injury. We also compared mean scale scores for those with a history of knee ligament injury to those with no prior history using independent t-tests. Similarly, we compared the results for the current study with previously published norms. **Main Outcome Measures:** The Knee Injury and Osteoarthritis Outcome Score (KOOS) and the Western Ontario and McMaster Universities Arthritis Index (WOMAC). **Results:** Among the 1177 subjects, 971 were males (18.8, ±0.9 years) and the remaining 206 were females (18.7, ±0.8 years). Among the males, 139 reported a prior history of knee ligament injury and 33 females reported a similar history. For those with no history of injury, the mean scale score for the five KOOS sub-scales by sex were: Pain (M=97.47±6.27; F=95.90±7.98), Symptoms (M=93.96 ±7.98; F= 92.90±8.99), Activities of Daily Living (M=98.86±3.83; F=97.92 ±4.80), Sports/Recreation Function (M=94.89±10.14; F=92.74 ±12.94) and Knee Related QOL (M= 92.62 ±11.20; F=90.51±13.84). All KOOS sub-scale scores including Pain (t=2.64, p=0.009), Symptoms (t=4.27, p=0.001), ADL (t=2.27, p=0.024), SRF (t=1.95, p=0.053), and KRQOL (t=4.72, p=0.001), as well as the WOMAC Stiffness (t=2.93, p=0.004) and Function (t=2.27, p=0.024) sub-scales, were significantly lower for males who reported a history of knee ligament injury. Only Knee Related QOL was significantly lower (t=3.51, p=0.039) among females with a history of prior knee ligament injury. When values for the KOOS were compared to previously published norms, scores were significantly higher for males only. **Conclusions:** Norms for the KOOS among males in this young and physically active population were significantly higher than those previously published. Despite meeting the medical standards for military service, subjects with a history of knee ligament injury had significantly lower KOOS and WOMAC scores upon entry to military service.

Efficacy of Anterior Cruciate Ligament Reconstruction in the Prevention of Knee Osteoarthritis: A Numbers Needed to Treat Analysis

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Context: Anterior cruciate ligament reconstruction (ACL-R) is primarily performed to improve knee joint stability, while secondarily it has been hypothesized to benefit long-term joint health by decreasing the risk of developing post-traumatic knee osteoarthritis (OA). A systematic evaluation of the current literature has not been performed to determine the effect of ACL-R on joint preservation. Knowing the prophylactic nature of ACL-R on knee OA is imperative for understanding the true benefits of this intervention. **Objective:** Determine the preventive nature of ACL-R compared to patients who remain ACL deficient (ACL-D) in the development of knee OA. **Sources:** An exhaustive search was performed using the Web of Science database from 1960 through August 2011 with the search terms*"osteoarthritis", "meni-sectomy", "anterior cruciate ligament", "ACL reconstruction"*,

and "ACL deficient". **Study Selection:** Sixteen studies reporting the incidence of tibiofemoral OA in ACL-R patients and/or ACL-D patients using radiographic assessments were included. Potential studies were excluded if OA incidence data was not provided or if patients presented with OA at the time of ACL injury. Study limitations included wide ranging patient populations, age, activity level, and follow-up time. OA grading scales were also not consistent across all studies, yet we were not concerned about the grade of OA, rather the presence of the disease. **Data Extraction:** Two investigators assessed study methods through the Critical Appraisal Skills Program. The number of patients with radiographically diagnosed knee OA were extracted from the total patients with ACL-D and ACL-R in each study. Additionally, the added risk of concomitant meniscal injury was analyzed. **Data Synthesis:** Numbers needed to treat (NNT; Numbers Needed to Treat to Benefit =NNTB and Harm=NNTH), and relative risk reduction (RRR; relative risk increase=RRI), with associated 95% confidence intervals were calculated for three separate groups including; 1) subgroup of patients with meniscal and ACL injury, 2) subgroup of patients with isolated ACL injury, 3) total patients (groups 1 and 2). Patients with a menisectomy and ACL-R yielded NNTB of 6 (NNTB 18.98 to 3.54) with an RRR of 29% (RRR 9% to 48%). Isolated ACL-R yielded a NNTH of 29 (NNTH 9.3 to •to NNTB 24.88) with a RRI of 67% (RRI:17% to 83%). In total, NNTB for patients receiving an ACL-R was 44 (NNTB 11.4 to •to NNTH 23.66) with a RRR of 6% (RRR 23% to RRI 11%). **Conclusions:** Overall the ACL-R intervention does not seem to be particularly effective at preventing tibiofemoral OA. However, when a meniscal injury, requiring meniscectomy, is present in combination with an ACL rupture, ACL-R seems to be beneficial in preventing OA. Conversely, this data indicates that ACL-R following isolated ACL rupture may increase the risk of OA development compared to those not receiving reconstruction.

Medication and Supplement Use for Managing Joint Symptoms Among Patients with Knee and Hip Osteoarthritis: A Cross-sectional Study

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Context: Osteoarthritis is an increasing concern among aging athletes with a history of joint trauma or participation in high-risk sports (e.g., soccer). To educate our patients about safe and effective methods to alleviate joint symptoms it is important to understand how patients with hip and knee osteoarthritis manage their symptoms. **Objective:** The purpose of the study was to determine the professionally-guided and self-guided medication use for joint pain management among patients with knee and/or hip osteoarthritis. **Design:** Cross-sectional study. Setting: Urban hospital-based outpatient orthopedic practice. **Patients:** A convenience sample of 184 patients with a primary complaint of hip or knee osteoarthritis was asked to participate. 22 participants were excluded or declined participate. Hence, 162 patients were included in the study: 67% female, 73% African descent, 59±10 years of age, body mass index = 35.1±7.6 kg/m^2, 57% report-ing a history of sport participation, 48% high school or equivalent education, 27% less than a high school or equivalent education, 93% knee osteoarthritis, and 77% moderate-severe radiographic osteoarthritis. **Interventions:** Four interview-based questionnaires were used to obtain information about the participant's health history and pharmacological/supplemental use. The questionnaires were developed by the research team and reviewed by two statisticians. All of the questionnaires were administered by one investigator. The interviewer practiced the procedures and data coding on 18 non-study patients with knee osteoarthritis prior to starting the study. **Main Outcome Measures:** The questionnaires were an item-by-item design, where each question could be scored individually. Logistic regression models and Fisher Exact Tests were performed to determine factors that may be associated with negative behaviors related to medication/supplement use. Odds ratios (OR) and 95% confidence intervals (CI) were calculated for significant findings. **Results:** Among the 162 participants, a majority reported professionally-guided recommendations and over 40% reported at least one self-guided intervention. 37 participants reported dual-use during the same day, and among those, 15 reported dual-use at the same time. Use of multiple medications or supplements in one day was more common among participants who reported osteoarthritis at multiple joints (OR [95%CI]=2.48 [1.03 to 5.96]) but less common among participants who did not complete high school (OR [95%CI]=0.26 [0.08 to 0.83]). Overall, 28% of participants reported their intervention as ineffective, sought an alternative method to achieve symptomatic relief, or were prescribed a stronger medication. Participants who reported not always taking their medication consistently for 2 weeks were more likely to report their medication as ineffective (OR [95% CI]=2.87 [1.19 to 6.92]). **Conclusions:** It is important for clinicians to discuss with patients how to effectively manage multiple joint symptoms, the importance of taking

medications as prescribed, and what they should do if they believe a treatment is ineffective or their medication runs out.

The Influence of Exercise Intensity on Serum Cartilage Oligomeric Matrix Protein (sCOMP)

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Context: Serum cartilage oligomeric matrix protein(sCOMP) is a biomarker elicited during cartilage degradation. Increases in sCOMP have been reported following single bouts of physical activity and over the duration of an athletic season. However, it is unknown what effects exercise intensity has on sCOMP levels when measured serially over time. **Objective:** To determine the influence of exercise intensity on sCOMP levels over the course of a soccer season. **Design**: Repeated-measures longitudinal cohort study. **Setting:** Laboratory. **Patients or Other Participants:** Six female Division-I soccer athletes (age:18.8 ±1.3 years; height: 168.9± 4.2cm; weight:67.1±7.4kgs) participated in 11 weekly(T0-T10) data collection sessions. Subjects were included if they participated in the 2011 spring soccer season and had no history of lower extremity surgery. **Interventions:** For the duration of the spring soccer season(T1-T8), minutes of participation in practice, agility, lifting, conditioning, and game play were documented each day and summed on a weekly basis. The week prior to participation(T0) and the weeks following participation(T9-10) served as controls as there was no formal athletic participation during these weeks. No data was collected for session T4. At each data collection session, subjects remained seated for 30 minutes before serum collection. Following the rest period, serum was collected from the antecubital vein, placed on ice, and transported to the laboratory. Serum was separated and placed in a-80°C freezer prior to analysis. ELISA tests were run for human sCOMP. Serum COMP values are expressed as ng/mL. The independent variable was time. **Main Outcome Measures:** Serum COMP values and weekly minutes of participation served as the dependent variables and were investigated over time using linear mixed models with random coefficients. Alpha was set at $p \leq 0.05$. Values are presented as mean±SD. **Results:** Baseline(T0) sCOMP values were 1249±227ng/mL. The total amount of minutes engaged in physical activity ranged from 330-840. For practice draws T1-T8, the highest sCOMP value was 1596± 287ng/mL(T7) in which the participants exhibited the greatest amount of athletic activity(840 minutes). Additionally, sCOMP values returned to levels similar to baseline in T9(1313±294ng/mL) and T10 (1275±174ng/mL)following cessation of intense physical activity. The results of the mixed model analysis was significant, p=0.025. This analysis determined that for every 100 minute increase in athletic activity, the average sCOMP levels increased by 53ng/mL(95% confidence interval: 8.4-98.4ng/mL). **Conclusions:** The results of this study demonstrated that exercise intensity (measured in minutes), does influence changes in sCOMP levels. Therefore, increases in intense physical activity result in greater sCOMP levels. These findings indicate that exercise intensity should be considered when monitoring sCOMP values in a physically active cohort. Future studies are necessary to determine if changes in this biomarker are representing a physiologic increase in cartilage turnover, or irreversible changes to the articular cartilage.

Ankle Dislocation with Maisonneuve Fracture: A Case Report

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Background: We present the case of an ankle dislocation complicated by a unique proximal fibula fracture in a high school football athlete. A healthy sixteen year old male running back suffered a direct blow to the lower extremity while being tackled. The tackler landed on the posterior aspect of the patient's left ankle and foot, causing the lower leg to internally rotate while the foot remained in a fixed position on the ground. Upon examination, a gross ankle deformity was noted as the foot remained in an externally rotated and pronated position. Distal circulation, sensation, and motor function were present however the patient was experiencing a significant amount of pain. The team physician diagnosed the injury on the field as a talocrural dislocation and performed a closed reduction at that time. Distal circulation, sensation, and motor function remained present after reduction however significant swelling was present. Nothing else was remarkable at that time. The ankle was then immobilized with a rigid splint and the patient was referred to the emergency department for further diagnostic testing. At the emergency department, radiographs confirmed that the patient had suffered an anterior talocrural dislocation with successful reduction and revealed an associated fracture of the medial malleolus. A fracture at the proximal fibular head was also noted. **Differential Diagnosis:** Talus fracture, tibia fracture, Weber or other fibula fracture, Pott's or Dupuyten's fracture, lateral collateral ligament sprain, deltoid ligament sprain, syndesmosis sprain. **Treatment:** The ankle was reduced on the field and immobilized. The patient was then referred to the emergency department and ultimately admitted for surgical intervention. The distal tibiofibular joint was stabilized with two screws inserted through the distal fibula extending through the syndesmosis and into the tibia. The tibial malleolar fracture was fixated with two more screw inserted directly into the medial malleolus from the distal end. Following surgery, the patient was placed non-weightbearing in a short leg cast for eight weeks followed by a program of therapeutic exercise to restore range of motion, strength, and neuromuscular control. **Uniqueness:** While distal fractures associated with ankle dislocations are common, proximal fractures are not. Maisonnueve fractures of the proximal fibula are associated with disruption of the tibiofibular syndesmosis, but are often missed during physical and radiographic exam. While most Maisonneuve fractures occur distal to the head of the fibula, the present injury occurred at the fibular head itself. **Conclusions:** Despite the location of the Maisonneuve fracture, surgical management of the injury was not different than if it had been it its typical location. The presence of a Maisonneuve fracture implies ligamentous ankle injury with potential instability not always apparent on static radiographs. It is imperative that clinicians are familiar with this injury and its clinical and radiographic presentation. If not managed properly, permanent disability and dysfunction could result. Early surgical intervention is recommended due to the potential instability associated with such an injury. In the present case, surgery and rehabilitation produced satisfactory results as athlete was able to return to play the following season.

Severe Presentation of an Electrolyte Imbalance in a High School Athlete

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Background: Athlete is a 16-year old male high school football athlete in South Florida. The athlete completed an evening football competition, mid season, and collapsed post-game walking into locker room. The Athletic Trainer (ATC) was called to the scene. Athlete was lying supine having difficulty breathing. He denied any injury during the game and denied hitting his head at time of collapse. Family was present and denied any other relevant medical history concerning the athlete. ATC conducted a general evaluation. Athlete's BP was 128/78, HR was 117, with respirations rapid and shallow. Within five minutes of initial collapse, athlete reported neck pain. ATC initiated inline cervical neck stabilization while another ATC on site began palpating cervical spine which revealed C5 and C6 point tenderness and EMS was summoned. Athlete was beginning to display decreased consciousness and alertness, numbness and tingling in facial region, along with bilateral extremity numbness in arms and legs. Athlete started to display decerebrate posturing. **Differential Diagnosis:** Subdural Hematoma, Upper Motor Neuron Lesion, Cervical Spine Fracture, Cervical Spine Sprain, Dehydration **Treatment:** Initial treatment consisted of maintaining cervical spine stabilization, controlling athlete's anxiety and accessory movements. EMS arrived and assisted with proper spine board transport of the athlete. Athlete was transported to local Emergency Room. During transport athlete was infused with two 1000 mL of normal saline intravenously. At ER, athlete underwent

diagnostic examinations which included radiographs, EKG, CBC, and other laboratory diagnostic tests. Radiographs and EKG were WNL. CBC was WNL, but the electrolyte screen indicated low potassium levels and marginally acceptable sodium levels. At the time of the CBC, the athlete had received two liters of normal saline IV fluids which likely elevated the sodium levels and the subsequent electrolyte screen was within an acceptable range. Athlete was discharged following evaluation from physician and instructed to follow-up with Pediatrician to reconduct CBC and Laboratory diagnostic tests four days post initial episode. The follow-up tests were WNL and athlete was officially diagnosed as suffering from transient hypokalemia secondary to dehydration. Athlete was cleared for full participation and has had no further episodes or problems. Following return to participation, the ATC began preventatively supplementing the athlete with 2 TSP of table salt in grape juice prior to game competition. This supports an action outlined in the NATA Fluid Replacement for Athletes Position Statement, suggesting the inclusion of sodium chloride treatment in extreme heat environments. This plan of action was collaborated with the physician based on the physiological properties of sodium chloride to promote acceptable potassium reabsorption. Athlete has anecdotally stated he has felt the best he ever has following competition and has had no further heat related problems or complaints. **Uniqueness:** Neurological symptoms are often a result of cervical neck injuries or a compounding factor with athletes suffering from heat stroke. In this case, the athlete had no cervical neck trauma or initial signs of heat related illness. The neurological signs and symptoms experienced were a result of the electrolyte imbalance; thus presenting signs and symptoms not commonly associated with initial heat related illnesses. **Conclusions:** This case highlights the diagnosis of an athlete suffering from hypokalemia. The athlete has made a full recovery; however, without proper referral, the outcome could have been more severe. The case also highlights the importance of critically evaluating the entire episode. The athlete's blood results would have been different if taken immediately prior to IV administration, most likely also revealing low sodium levels. Care should be taken when administering supplemental potassium as this can lead to cardiac arrest. By supplementing the athlete with sodium, potassium reabsorption is maintained, thus preventing hypokalemia.

Ankle Sprain Leads to Chronic Regional Pain Syndrome in Football Player

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Background: A 17 year old male high school football player presented to the outpatient clinic with a chief complaint of left ankle pain. Patient described an inversion ankle injury during a game 7 days prior with no history of previous injuries. Since the injury, the patient said he had been nonweightbearing while applying ice, consuming ibuprofen, and going to therapy. Pain was listed at a 6 on a 10 point scale with tenderness around the lateral ankle with neither proximally nor distally radiating pain. Edema was noted around the lateral aspect of the ankle with ecchymosis along the lateral aspect of the foot. Range of motion was limited due to pain with a decreased sensation on the dorsal aspect of the foot. The posterior tibia and dorsalis pedis pulses were palpatable. **Differential Diagnosis:** Possible injuries include lateral ankle sprain, distal fibula fracture, syndesmotic sprain, osteochondral defect, and peroneal tendon strain. **Treatment:** X-rays showed a possible nondisplaced fracture of the distal fibula, due to changes in the cortex, with no widening of the ankle joint. Initially, the patient was diagnosed with a lateral ankle sprain with a possible nondisplaced distal fibula fracture. The patient was placed in a nonweight-bearing cast and instructed to return 1 week later while performing toe wiggles in the meantime. The patient returned 11 days later for removal of cast and reexamination. His pain level and localization was consistent with initial evaluation. Range of motion continued to be limited with residual edema present. A positive tinel's sign at the left fibular head was noted with prolonging decreased sensations of the dorsal aspect of the foot. X-rays were retaken revealing the questionable nondisplaced fracture of the distal fibula. Patient was placed in a walking boot, given a physical therapy prescription, and scheduled for a follow up visit in 2 weeks. The patient returned 14 days later for reevaluation. A significant bluish purple discoloration of his foot was noted in a gravity dependent position. The patient had neurologic symptoms of dysesthesia over the lateral foot that does not follow dermatomal patterns with the decreased range of motion of the ankle. A MRI, that was ordered by his PCP, showed a subacute tear of the anterior talofibular ligament and bone marrow edema of the bilateral malleoli , talus, and calcaneus consistent with a healing contusion. A secondary diagnosis was imparted of a lateral ankle sprain with the beginning development of chronic regional pain syndrome. The patient was instructed to continue physical therapy, given a plastic type ankle brace to assist with his drop foot, and scheduled for an EMG and nerve conduction study. The patient returned 5 days later. The EMG and nerve conduction study resulted as normal with the decreased range of motion noted. The discoloration appeared vasomotor in nature. Some of his numbness has resolved. A final diagnosis of a lateral ankle sprain with chronic regional pain syndrome was given, while instructed to continue physical therapy and change his plastic type ankle brace to a lace up style ankle brace. **Uniqueness:** With only an occurrence of 26.2 per 100,000 annually, chronic regional pain syndrome rarely develops from an

associated trauma. **Conclusions:** Inversion ankle sprains rarely change into a disorder that is more debilitating than originally perceived. However, signs and symptoms that are atypical of an inversion ankle sprain need to be taken into account for other developments that might arise.

Hypertension Exacerbates Symptoms of Concussion in High School Football Player

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Background: Our subject is a 16 year-old male American football linebacker (height: 183.3 cm., weight: 89 kg). In May 2011, our subject checked his blood pressure "as a joke" on an automated supermarket sphygmomanometer. His systolic pressure was 160 mm/Hg. He then visited a physician to investigate his hypertension as part of his sports physical. The physician did not clear him for sports because of his elevated blood pressure. He then consulted his family physician who referred him to a pediatric cardiologist. Our subject has a family history of hypertension on his paternal side. The subject indicated he occasionally experienced chest discomfort lasting a few seconds per episode. There was not a history of dependent edema, dyspnea with exertion, or syncope; however, he did have occasional orthostatic dizziness. He had a history of a significant concussion in 2008 while skate boarding. He experienced vision issues and prolonged symptoms following this event. In June 2011, his cardiologist prescribed an ACE inhibitor, lisinopril, starting with 5 mg daily to control his hypertension. In July 2011, in spite of a still slightly elevated blood pressure, he was cleared to participate in a summer football camp. He sustained another concussion during this camp and was removed from competition for the week. When fall practice began nearly a month later (August 2011), he denied any post-concussion symptoms. He sustained another concussion during the first week of formal practice with severe symptoms. Following this concussion, he "came clean" admitting the symptoms from the camp concussion had not previously resolved. When school started, his friends noticed a difference in his personality with mood swings and increased emotions. He had difficulty hard time remembering conversations with his friends. Because of his inability to concentrate, he dropped his two most difficult classes. Other physical symptoms, such as headache, also continued. **Differential Diagnosis:** essential hypertension, malignant hypertension, concussion, hypertrophic cardiomyopathy, renal artery stenosis **Treatment:** When the initial dose of lisinopril was not effective, the dose was increased to 10 mg and finally to 20 mg. In September 2011, the lisinopril was still not effective in lowering the blood pressure. A switch to a calcium-channel blocker, amlodipine (5 mg daily) was made. Amlodipine has been effective in controlling his hypertension. We noted a relationship in the reduction of his headache symptoms (one month post-concussion) and the lowering of his blood pressure with the amlodipine. His echocardiogram revealed no cardiac abnormalities. His pediatric cardiologist referred him to a nephrologist for two separate ultrasound evaluations. Both of which revealed no abnormalities of his kidneys that might be causing the hypertension. An imPACT neuropsychological test was administered on November 3, 2011 with results equal to his 2009 baseline. **Uniqueness:** It is the concurring opinion of his physicians that his hypertension may have played a role in the exacerbating his concussion symptoms. This drives home the point that athletic trainers need to consider other underlying issues that can intensify concussive symptoms. In his case, his hypertension may have been issue in prolonging his headache and other concussive symptoms. **Conclusions:** He was cleared to return to football in November 2011, but did not return since only two games remained in the season. His headache and concentration difficulties lasted nearly two months. His cardiologist diagnosed his hypertension as essential and recommended controlling with continued exercise, proper nutrition, and medication. With his concussion symptoms gone and blood pressure under control, he had been working out regularly and planning to return to football for the 2012 season. However, there are some unresolved health issues including his multiple concussions and chest pain episodes that need to be addressed.

Great Toe Pain in a High School Football Player

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Background: A 17 year old high school football player reported with insidious onset of pain in and around the left great toe. He stated that he had been treated for 'turf toe' in the same foot during the previous football season but that had resolved following completion of the football season. The athlete stated the he participated in both basketball and track seasons with no complaint. Upon resuming football related activities during the summer, the pain gradually increased to the point in which he was unable to run due to the severity of the pain. Upon evaluation, the athlete presented with a neutral arch but did present with keratosis around the fist ray, first metatarsophalangeal joint and 1st metatarsal head. The athlete did report that he has been treated for hyperkeratoic lesions previously. The athlete was point tender over the 1st metatarsophalangeal joint, the base of the distal 1st metatarsal and the seasmoid bones. The athlete complained of pain with valgus and varus stress test at the 1st metatarsophalangeal joint. He also had pain with active and resistive great toe

flexion and with passive great toe extension. **Differential Diagnosis:** Hallux rigidus, 1st metatarsophalangeal joint sprain (turf toe), sesamoiditis, bipartite sesamoid, sesamoid fracture. **Treatment:** Protective taping for 1st metatarsophalangeal sprain did not relieve pain. Athlete was seen by team physician. X-ray was inconclusive for sesamoid fracture. MRI revealed early avascular necrosis and an occult fracture of the medial sesamoid. The lateral sesamoid was within normal limits. The athlete was referred to a podiatrist to discuss surgical intervention. Based on consultation with podiatrist, it was determined that the athlete could return to football activities with the understanding that he may a have periodic episodes of pain that could limit his full activity level. It was also suggested to the athlete that he continue to tape his great toe along with a donut pad over the involved sesamoid. Both doctors also suggested that if possible, he should remove the football cleat located in that area to eliminate any potential irritation. **Uniqueness:** Avascular necrosis is not commonly associated with the sesamoids and is usually the last diagnosis of plantar pain to the first metatarsophalangeal joint. Typically the patient will complain of pain on the plantar aspect of the first metatarso-phalangeal joint. A pedal exam can show edema and erythema to the involved area. Pain will be elicited with palpation of the area and with passive range of motion. Aggravating factors include the use of high-heeled shoes and repetitive stresses to the sesamoid complex. **Conclusions:** With conservative treatment, the athlete has had minimal complaints of great toe pain. The athlete has continued to have his great toe taped for each practice and game, but it appears that the removal of the football cleat immediately under the area of the sesamoid has provided the most relief. Upon conclusion of the football season, the athlete will return for follow-up with the podiatrist to determine whether surgical intervention is necessary. The athlete is intending to continue his football career at the collegiate level.

First Rib Fracture in a Collegiate Football Player

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Background: A 20 year-old male football player was struck to the right shoulder during a kick-off return drill during a collegiate football practice. The athlete complained of immediate pain and also pain with forward flexion. The initial exam revealed anterior shoulder pain and the inability to forward flex and abduct the shoulder with applied resistance. The athlete had no pain to palpation over the AC joint, but curiously had moderate pain along the distal scapula. No tenderness along the cervical spine and moderate pain along the superior trapezius. He had full cervical spine range of motion. There was no clavicle pain or deformity. No glenohumeral instability noted and glenoid labrum test were deferred. There was no pain with respiration and no neurovascular symptoms present. **Differential Diagnosis**: shoulder contusion, muscular strain to the superior trapezius, AC joint sprain, scapula fracture, clavicle fracture, or rib fracture. **Treatment**: The athlete was treated with ice and placed in an arm sling and referred the next day to the team physician for evaluation and x-ray. The next day, x-rays revealed a transverse fracture to the first rib. The athlete remained in the arm sling and withheld from football activity but permitted to ride a stationary bike for exercise. The use of thermal modalities began 72 hours post-trauma. At 10 days the athlete was pain-free with gleno-humeral range of motion and began rotator cuff exercises with the elbow adducted using elastic tubing. Gleno-humeral joint distraction was noted to be aggravating and therefore was to be avoided. The athlete could begin forward and lateral raises dumb-bellsraises from 45-90 degrees as no pain was elicited. He also could perform biceps and triceps strengthening,along with seated rows using elastic tubing. At two weeks repeat x-rays revealed continued fracture line with no evidence of bony union and the athlete was point tender over the superior trapezius muscle. He also had pain with resisted cervical motion. There was no neurovascular compromise to the upper extremity. When not participating in therapy, the athlete was instructed to wear the arm sling and refrain from overhead activity. Repeat x-rays at six weeks showed significant boney calcification beginning to occur at the fracture site. At ten weeks, x-rays showed the fracture site with full boney union. **Uniqueness**: According to the literature, first rib fracture injuries are the rarest of all all rib injuries. The mechanism of injury is similar to that which causes AC sprains and clavicle fractures. First rib fractures often result from severe direct trauma to the chest and upper torso.A thorough literature search revealed few articles relating to acute isolated first rib fracture injuries, particularly in athletes. First rib fractures can occur in throwing athletes and present as a stress fracture. First rib stress fractures may often present with associated scapular pain. Most authors recommend conservative treatment of first rib fracture injuries. **Conclusions:** This case demonstrates the necessity of prompt recognition and treatment of an unusual rib injury diagnosed as a fracture. It also supports the non-operative management and care of first rib fracture injuries. Proper care and rehabilitation is required for return to active participation in athletic activities with this type of injury. Because of the time loss from football activity, the athlete successfully applied for a medical hardship waiver. The athlete at this time is asymptomatic and has returned to all athletic and daily living activities.

Management of a Case of Common Variable Immune Deficiency in a Collegiate Gymnast

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Background: The athlete is an eighteen-year-old female inter-collegiate gymnast who began gymnastics at age 4. Between ages 5 to 9 shebegan having recurrent cases of sinusitis,bronchitis (three episodes), pneumonia (2 episodes), and had her tonsils removed. Her parents and coaches noticed that she was more fatigued with participating in gymnastics. She did not respond well to treatment with over-the-counter medications or antibiotics. At age 9, she was referred to an infectious disease specialist and lab studies revealed depressed levels of IgG (immunoglobulin gamma) concentrations. IgG is an antibody found in human blood that plays three main roles in adaptive immunity: (1) neutralizes foreign antigens through direct binding, (2) alters antigens to allow for phagocyte engulfment, and (3) triggers release of cytokines and chemokines to destroy foreign antigens. Normal IgG values range between 700- 1400 mg/dl; this athlete's initial IgG values were around300 mg/dl. **Differential Diagnosis:** Bone marrow deficiency, leukemia, immune deficiency. Laboratory tests confirmed that the athlete was positive for Common Variable Immune Deficiency (CVID). CVID occurs due to a genetic mutation in the blood with an idiopathic etiology. In patients with CVID, the immune system does not produce enough antibodies to destroy invading microorganisms that can cause bacterial and viral infections, thus, increasing susceptibility to infection. **Treatment:** The athlete was treated with an antibody-replenishing treatment known as intravenous immunoglobulins (IVIG) every 21 days; this IVIG includes Gammagard, Benadryl, and Solu-Cortef. The immunoglobulins are pooled from thousands of donors who have been screened for various diseases. Patients receiving IVIG are not able to complete physical activity for 24 hours post-treatment. Side effects of IVIG treatment are generally mild and include headaches, short term fatigue, chills, and nausea. Some serious side effects, although less common, include transmission of hepatitis C and meningitis, renal failure, and anaphylaxis. Along with IVIG treatment, many patients are given diuretics as well. This can cause an imbalance of sodium and potassium levels within the body, making patients more susceptible to muscle cramps and dehydration. **Uniqueness:** The estimated prevalence of CVIDin the general population is 1 in 20,000 to 100,000 people. CVID statistics in collegiate athletes are unknown because often this condition is not diagnosed until adulthood. Fortunately, IVIG treatment greatly increases a person's quality of life and reduces the risk of persistent infection by way of passive immunity. Donor antibodies protect the patient receiving IVIG treatment because patients with CVID are not able to produce enough antibodies on their own. IVIG does not eliminate CVID nor does it completely abolish the risk of infection. For this reason, many children with this disease are removed from public schools and extra-curricular activities. The cost of IVIG treatments are between $10,000- $15,000per treatment. **Conclusions:** CVID is a very rare condition found in the general public and even less common in athletes. Athletic trainers who are managing athletes with CVID need to pay close attention to the athlete's daily health status. If not properly managed, e.g. an athlete misses an IVIG treatment, athletes with CVID can suffer serious consequences such as persistent infections, splenomegaly, and uncommonly, death from even mild upper respiratory infections. Good communication between the athlete and athletic trainer is imperative. Athletic trainers can help athletes with CVID manage their condition by teaching them to properly monitor hydration levels at appropriate times depending on their sport, as well as making the proper medical referrals when athletes have persistent or recurrent cold or flu-like symptoms.

Objective Assessment of Function following Head Injury using Movement and Activity in Physical Space (MAPS) Scores: A Case Report

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Background: A 21 year old NCAA Division III women's soccer midfielder suffered a blow to the back of the head from an opponent's shoulder while participating in an away match. There was no athletic trainer present to immediately diagnose the injury. The patient reported to the athletic training room the following day complaining of a headache, "pressure in the head", dizziness, confusion, not "feeling right", light sensitivity, feeling "slowed down", difficulty concentrating and remembering, fatigue, drowsiness, and being emotional. A thorough head and cervical spine examination was performed. Vital signs and cranial nerve function were within normal limits. The Sport Concussion Assessment Tool 2 (SCAT2) was administered post-injury yielding a total score of 67 of 105, substantially lower than her baseline score of 98 of 105. The purpose of this case report is to highlight the use of an objective functional measure, the Movement and Activity in Physical Space (MAPS) scores following injury. **Differential Diagnosis**: Concussion, mild traumatic brain injury, intracranial hemorrhage. **Treatment**: The athlete was removed from activities. Symptoms were monitored based on the Zurich guidelines. She was also instructed to wear a beeper sized accelerometer on her hip and to carry

an on-person Global Positioning System (GPS) receiver at all times for 10 days except for when sleeping or bathing. These devices measure physical activity (intensity) each minute and location (latitude/longitude). Daily MAPS scores were calculated by combining data from the GPS and accelerometer for each day during the recovery period to assess the patient's level of function in free-living conditions. She was asymptomatic five days after the injury and began a gradual return to play protocol on day six. This protocol involved light activity that progressed to moderate/vigorous activity and finally returning to practice (day nine) following clearance by a physician. The MAPS data, representing the patient's interaction within her environment, were analyzed to provide an objective measure of function following injury. **Uniqueness**: We monitored the patient's function during the concussion recovery process using GPS and accelerometers creating MAPS scores. This novel approach to measuring function following injury may provide a useful complimentary tool to objectively determine return to play status. In this case the patient's symptom totals for the four symptomatic days were 82, 39, 49, and 36 (mean 51.5). Her MAPS scores for days 2-4 were 865.2, 815.4, and 1022.1 (No MAPS score was calculated for day one because it was not a full day). Her mean MAPS functional score while symptomatic was 900.9, and while asymptomatic 2734.9 representing a three-fold increase. An interesting observation was that on day three she attended a volleyball game which increased her symptoms. This increase in symptoms was also reflected in her MAPS score for that day which decreased from 865 to 815. **Conclusions**: GPS and accelerometers were used to observe the patient's physical activity in a free-living environment, allowing for an objective measure of function during recovery. MAPS scores were low while she was symptomatic and increased as she became asymptomatic. In this case, we saw the expected inverse relationship between symptoms and function. In situations where accuracy of reported symptoms may be a concern, this measure may provide a way to verify the validity of, or raise doubts, about self-reported symptoms. Current concussion assessment tools focus on symptoms and impairments and are largely subjective in nature. MAPS scores present an objective way for athletic trainers to measure athlete function following concussion, which may be used as part of the return to play decision.

Diagnosis and Management of a Lateral Abdominal Wall Hematoma After a Motorcycle Accident: A Case Study

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Background: The purpose of this case report is to document the treatment and outcome of a right lateral abdominal wall hematoma in a 28-year-old male, Caucasian Information Systems Analyst. The patient was involved in a non-fatal motorcycle ejection after colliding with another vehicle, landing chest first on the pavement. Evaluated at the emergency department, diagnostic testing (MRI and radiographs) for visceral and bony trauma was negative. He was released that evening. After twenty-four hours a large hematoma had formed; 6-8 hours later it had begun to harden. On follow-up with his primary physician 12 days later his diagnosis was a right lateral abdominal wall hematoma and the patient was referred to physical therapy for evaluation and treatment. **Differential Diagnosis:** Fibromatosis, abdominal wall herniation, abdominal wall rupture, abdominal aneurysm, rib fracture, peritonitis, intra-abdominal or subcutaneous hematoma. **Treatment:** Examination by an athletic trainer/physical therapist revealed a moderately sized, 23.1 cm x 18 cm (inferior-superior, medial-lateral, respectively) circular mass protruding from the right lateral abdominal wall. Also noted were several small abrasions and one healing laceration along with evidence of ecchymosis around the mass. The patient was non-tender to palpation; however, adhesions were noted within the center. There were no functional restrictions or inhibition in breathing. A rehabilitation protocol to reduce the mass' size included: therapeutic ultrasound (avoiding open wounds) at 3.3 MHz (20% duty cycle; spatial average intensity=1.3 W/cm^2) to facilitate healing and promote blood flow and manual therapy. Manual therapy consisted of superficial and deep effleurage massage to encourage venous and lymphatic return. A lymphatic corrective Kinesio®-taping application to the lateral abdominal wall to create space and provide a channel for fluid to move towards the lymph nodes was also initiated. Eight treatments later the mass measured 22.5 cm x 18.9 cm (inferior-superior and medial-lateral, respectively). The patient was referred to a Certified Lymphedema Specialist. Following the physical examination the specialist recommend a course of decongestive therapy and manual lymph drainage. The lymphatic drainage techniques used were "Stirring the Well" and "Opening the Trenches". After four treatments the hematoma demonstrated some reduction in size, 19 cm x 18cm (inferior-superior and medial-lateral, respectively). The patient was educated on how to perform the technique at home and reported being compliant; however, no significant reduction in mass size occurred. **Uniqueness:** The formation of lateral abdominal wall hematomas are not commonly reported in the literature, and typically are managed though surgical intervention due to the lack of progress with conservative treatment. Other reported cases that present with hematomas of this size eventually encapsulate around the necrotic tissue thereby making it impossible for conservative treatment alone to resolve the condition. In this case, the referring physician opted for a

conservative approach rather than an invasive surgical procedure. And while the decongestive therapy and manual lymph drainage demonstrated some improvements in mass size compared to therapeutic ultrasound and Kinesio®-taping alone, the overall improvement has not shown significant signs of resolution. Further care will likely be warranted to aid in the resolution of the hematoma because conservative treatment alone has not been successful. **Conclusions:** Certified athletic trainers are well trained in the management of localized hematomas to the extremities caused by blunt force trauma from projectiles, equipment, and other athlete-to-athlete contact. However, lateral abdominal walls hematomas, such as the one presented in this case offer a unique experience because of the mechanism of the injury, the extent of the condition and failure to resolve with conservative care. In situations where conservative care fails to resolve the condition, referral to appropriate healthcare providers for further evaluation and alternative therapy or surgical intervention may be necessary.

Abnormal Heart Rhythm in Collegiate Female Basketball Player

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Background: A 21-year-old female basketball guard presented with an unstable heart rhythm that was identified after volunteering in an exercise physiology experimental study. Physical examination identified a slight pause in between heartbeats. The patient stated that this occurred regularly, but did not report it to the team's medical staff. She was subsequently removed from participation and referred to campus health services. The patient's family and personal medical history was not significant for cardiac conditions and the pre-participation physical examination performed by her primary care physician did not reveal any cardiac abnormalities. **Differential Diagnosis:** congenital heart defect (atrial/ventricular septal defect), heart muscle condition (myocarditis, cardiomyopathy), heart murmur (mitral valve prolapse/regurgitation/ stenosis, aortic stenosis/sclerosis/ regurgitation), Arrythmia (Supra-ventricular tachycardia, proxysmal supraventricular tachycardia, sinus tachycardia, bundle-branch block, atrial fibrillation). **Treatment:** After the initial consultation with the primary care physician, she was referred to a cardiologist. The cardiologist ordered a 24-hour Holter test which indicated a heart rate of 38-126 bpm with an average of 65 bpm. Also, the 24-hour Holter test revealed a 1º and 2º atrioventricular block, a disruption of nerve conduction in the heart that resulted in pauses, as well as 341 isolated premature ventricular contractions, which were asymptomatic and occurred mostly during sleep. Furthermore, the 24-hour Holter test revealed 5 episodes of tachycardia, 33 episodes of bradycardia, and 130 pauses greater than 2 seconds, with the longest pause being 2.2 seconds. Further diagnostic testing included an electrocardiogram to evaluate the electrical activity and an echocardiogram to evaluate the ventricles and valve functions. The electrocardiogram was within normal limits; however, the echocardiogram revealed minor mitral valve regurgitation with normal mitral valve appearance, trace tricuspid valve regurgitation with normal appearance, and trace pulmonic valve regurgitation with normal appearance. Upon completion of diagnostic testing, the cardiologist diagnosed the condition as 1º and 2º atrioventricular block with mild mitral valve regurgitation. After discussing the diagnoses, the patient was not prescribed medication and was subsequently cleared for unrestricted activity pending careful monitoring by the athletic trainer. **Uniqueness:** Cardiac conditions are unique in collegiate athletes and can jeopardize an athlete's career and life. Despite being diagnosed with 1º and 2º atrioventricular block with mild mitral valve regurgitation, the patient was able to participate for an entire season. This case is also unique because she did not present with significant symptoms during the season, did not notify any medical professionals when she noticed any abnormal heart rhythms, and was cleared for unrestricted activity pending careful monitoring by the athletic trainer. **Conclusion:** If a cardiac condition is present, it will most often be found during the pre-participation screening process. In this instance however, the condition was not identified during the pre-participation screening and the athlete participated without identification of the condition. Although many medical organizations do not support advanced cardiovascular screening for athletic participation, more thorough cardiac screenings may be necessary for athletic trainers to adequately identify and prevent sudden cardiac pathologies that may arise. Advanced cardiovascular screenings could be performed during pre-participation screenings to ensure safe participation. Additionally, athletic participants should be educated about the warning signs and symptoms of cardiovascular conditions so that they may feel comfortable reporting them to their athletic trainer or other appropriate health care providers. As such, this case demonstrates that athletic trainers will have exposure to patients suffering from cardiovascular conditions and should be able to identify, educate, and monitor participants with cardiac symptoms which may include sweating, pallor, palpitations, anxiety, exertional or non-exertional chest pain, dizziness, nausea, dyspnea, hypertension, hypotension, epigastric pain, as well as being asymptomatic.

Fibromyalgia in a 19 yo College Student

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Background: 19 y.o., female Hispanic college student. Patient reported she was seeing counselor for depression and had general pain and fatigue for last 3 months. Palpation of American College of Rheumatology patient sensitivity points and sham point identified 14 hypersensitive areas of pain. Sham points were negative. **Differential Diagnosis:** Fibromyalgia or Rheumatoid Arthritis. **Treatment:** Physician diagnosed patient with fibromyalgia. Treatment consisted of low level Laser therapy twice per week. Each treatment day the patient identified areas of sensitivity using standard fibromyalgia sensitivity chart which consists of 18 points from the American College of Rheumatology Widespread pain index (WPI). The patient rated pain level (1-10) for each sensitivity point pre- and post-LASER treatment. LASER treatment consisted of Sweep program (5-1000 Hz) 2 minutes each tender spot. The low level laser used a LASER Shower consisting of six 50W Laser diodes (905 nm) and four 25W Infrared diode (660nm). A total of 4 treatment sessions (2/wk for two weeks) were given. Additionally, the patient completed a Fibromyalgia Impact Questionnaire (FIQ) each week to determine the effect of the LASER treatment on the patient's daily life. The FIQ is a standard questionnaire used to determine the impact of fibromyalgia on the patient's daily life and is a composite score out of 100. The FIQ consists of 10 questions that score the patients physical impairment, feel good, work missed, do work, pain, fatigue, rested, stiffness, anxiety, and depression. The lower the score the better the patient feels on a daily basis. The average fibromyalgia patient scores around 50 and severely afflicted patients are approximately 70. Subjective *Activity of Daily Living (SADL) subscale from the FIQ* uses the first question which consists of 11 items rating their ability (0=Always to 3=Never) to perform activities. The overall score on this section has been used as a subjective measure of the patients function, the lower the score the grater the function. The following measures were used to determine the effect of the laser treatment: number of painful sites, pain levels pre- and post LASER treatment at each site, and weekly FIQ scores. Pre-treatment FIQ 82, after first treatment it decreased to 67, after the second week (4 laser treatments) the FIQ score was 23 and the total number of active tender points decreased from 14 to 6. SADL scores decreased from 20 to 5. Treatments were not given for two weeks due to patient unable to attend therapy. During this time the FIQ scores increased to 33.86 and the number of active points increased to 14. However, the SADL score decreased to 0. The immediate effect of the LASER treatment was seen in the average decrease of 3.5 points on pain scale from pre- to post- LASER treatment. **Uniqueness:** According to the American College of Rheumatology, fibromyalgia currently affects 2-5% of the population with onset occurring typically in middle adulthood. Our patient was 19 years old, which is quite young for adult Fibromyalgia. However, Juvenile Primary Fibromyalgia Syndrome (JPFS) occurs in as high as 6% of the population with a mean onset of 12 years old. There is an increase in JPFS which occurs during high school aged children. It is possible that as an athletic trainer you may treat an athlete that was diagnosed with fibromyalgia. Typically, patients are prescribed pain medication (*Lexica*or *Nerotin)* to control pain levels. We used LASER treatment regimen. We used a non-pharmacological LASER as our primary treatment which significantly decreased the patient's pain and increased her function. **Conclusions:** LASER is a viable non-pharmacological treatment to reduce pain and increase function in patients with Fibromyalgia.

Scaphoid Cyst in a Collegiate Softball Pitcher

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Background: A 20-year-old female softball pitcher presented complaining of moderate to severe left wrist pain rated at an 8/10 over the scaphoid navicular bone upon awakening. There was no mechanism of injury and the athlete had no history of left wrist injury. Physical examination revealed long bone compression test, lunate dislocation test, and flick test were all negative and Phalen's and Tinel's tests were positive for possible median nerve compression. Cause of the compression was unknown, as resistive range of motion revealed good strength in all planes of motion, with pain of 8/10 resulting from pronation and extension of the wrist. Active and passive pronation and extension also resulted in 8/10 pain, and the athlete had complained of pain catching the ball during this motion as well. No other motions caused a painful response. The athlete complained of numbness and tingling through the left hand and fingers, particularly through the innervation of the median nerve, but no myotome or dermatome deficiencies could be found. A cock up splint was used on the left wrist for four days, which relieved numbness and tingling through the fingers, but did not decrease pain substantially. The athlete was then referred to an orthopedic Physician Assistant. **Differential Diagnosis:** Differential diagnoses included scaphoid navicular fracture, scaphoid cyst, separation of the scapholunate junction, lunate dislocation, extensor strain, pronator strain, and median nerve compression due to an awkward sleeping position. **Treatment:** X-ray and Magnetic Resonance Imaging (MRI) results after 4 days in a cock up splint revealed a large cyst over the scaphoid bone, and a Computerized Tomography (CT) scan showed no evidence of fracture. The athlete was placed in a thumb spica brace for two

weeks, followed by progression back into activity as long as her symptoms did not increase. She was also informed by both the physician and the athletic trainer she was at higher risk of fracture because of the cyst. At this time the athlete is no longer with the team. **Uniqueness:** The athlete had no mechanism of injury or previous history of wrist pain, and the cyst was located on the athlete's glove hand. Also, the athlete had neurological symptoms indicative of possible carpal tunnel syndrome, yet MRI results did not specify entrapment of the median nerve, and a cock up splint relieved symptoms. **Conclusions**: The fact that there was no mechanism involved and the athlete had no history illustrate the importance for a complete and thorough history and medical examination. Imaging and painful range of motion proved to be very important in the diagnosis of this condition. This athlete was at increased risk for fracture because of the cyst, which presented like a neurologic condition.

Nonunion of Acromial Fracture: an Unusual Cause of Shoulder Pain in a College Football Player

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Background: A 23 year old male college football player suffered a direct hit to his right shoulder from another player resulting in severe pain. He was diagnosed with a sprained shoulder. He had previously seen another orthopedic surgeon for this injury and received a cortisone injection as well as formalized physical therapy for three weeks. However, he never fully returned to his original strength and functionality. He had no other significant past medical history. At the time of presentation he complained of pain, weakness, stiffness, popping and catching in the right shoulder. On physical examination, he was tender to palpation at the right acromion and acromioclavicular joint. His active range of motion measured 175° flexion on the right, 180° on the left; 160° abduction on the right, 180° on the left; 80° external rotation on the right, 80° on the left; and internal rotation reached T10 on the right and left. He had a positive O'Brien's test and cross arm adduction produced pain and discomfort at the acromion area. All other special tests performed were negative. The patient had full and symmetric sensation, motor function and reflexes of the upper extremities. **Differential Diagnosis**: Acromial nonunion, glenoid labrum tear, acromioclavicular joint pathology, rotator cuff tendonitis. **Treatment:** Plain radiographs and an MRI revealed a hypertrophic non-union of the right acromion, splitting of the deltoid fibers attaching at this site, a chronic AC joint separation with superior displacement, and an anterior labrum tear with a paralabral ganglion cyst. Having failed non-operative treatment, the patient underwent a right shoulder arthroscopy with an anterior labral repair. This was followed by anopen reduction and internal fixationof the acromial nonunion with rigid plating and local bone grafting.While preparing the acromial nonunion site, significant amounts of soft tissue and mature bony callus were found between the two bone fragments. This was removed and the bone was debrided to a bleeding bone surface. Following open reduction and internal fixation with a locking plate and screws, a bone graft substitute and the previously debrided bone fragment were used to fill the nonunion site. The AC joint was not treated at the same time so as not to destabilize or devascularize the site further. **Uniqueness**: Acromion fractures are rare fractures accounting for less than one percentof all fractures. They present with similar symptoms to the more common AC joint sprain, and therefore could be overlooked. This case involved a patient whom was diagnosed with a sprain of the AC joint without radiographic evaluation. This led to a symptomatic nonunion of the acromial fracture. It is important to complete a thorough evaluation of orthopaedic injuries in order to properly treat and hopefully prevent further injury. When symptoms fail to resolve additional imaging may be needed. **Conclusions:** This case report involves a 23 year old college football player who sustained a fracture to his acromion. He was not properly diagnosed immediately and developed a nonunion. Eventually he underwent an open reduction and internal fixation of a non-union at the acromion approximately one year after the initial injury. Postoperatively he worked with a physical therapist to regain active and passive motion of the right shoulder and remained protected in his sling for 6 weeks postop. At 8 weeks,he will begin strengthening of the shoulder. It is expected that he will return to normal functionality, range of motion, and sports at approximately 4 months from his date of surgery.

Case of Sternoclavicular Reconstruction in a Male Professional Rescue Diver

Dee AE, Petre B, Ashton J, Hackett TR: The Steadman Clinic, Vail, CO

Background: This case is of a 59 year old male, right-hand dominant, professional rescue diver with severe sternoclavicular joint (SCJ) pain. He sustained a fall into a man hole at work that resulted in an anterior SCJ dislocation and rotator cuff tear. He underwent a right arthroscopic supraspinatus and infraspinatus rotator cuff repair followed by an open repair of the subscapularis, subacromial decompression, distal clavicle resection, open biceps tenodesis and a debridement of a type 2 SLAP lesion on June 30, 2010 at a separate clinic. Several months after the procedure, debilitating SCJ pain was still present. He had multiple injections and an extensive course of physical therapy, all of which provided minimal pain relief. Finally, two separate treatment options were discussed; continuation of his current protocol or an additional procedure consisting of a medial clavicle excision. The patient presented to the Steadman Clinic for a second opinion on March 23, 2011.

Upon initial evaluation; right SCJ pain was reported ranging from 4/10 at rest to 8/10 at its worst on the visual analog scale. He was tender to palpation over the SCJ and anterior protrusion of the medial clavicle was noted. Full shoulder range of motion (ROM) was symmetric bilaterally, and 5/5 manual muscle testing of rotator cuff strength with the exception of infraspinatus; 4+/5 with pain, were measured. **Differential Diagnosis:** Sternoclavicular dislocation, sternoclavicular subluxation, sternoclavicular sprain, SCJ arthritis, and clavicle pain secondary to surgery. **Treatment:** X-ray and CT were obtained. Two views of the clavicle revealed abnormal alignment of the SCJ. The CT showed extensive degenerative changes of the SC joint. The patient was diagnosed with SCJ dislocation/pain and was given several options of treatment with SC reconstruction being one of them. After failing numerous conservative treatments over 14 months, previous surgery, and an inability to return to work, the patient underwent a sternoclavicular reconstruction with a palmaris longus autograft on August 30th, 2011. The patient is now three months status post reconstruction and is currently undergoing physical therapy with no complications and minimal pain. **Uniqueness:** The SCJ is one of the least commonly dislocated joints in the body, constituting only about 3% of all shoulder pathology. Trauma to posterior-lateral shoulder providing a medial force into the glenohumeral joint is transmitted to the SC joint and is the most common means of a traumatic SC injury. It is most often seen in young males due to participation in extreme activities. Sternoclavicular dislocation/subluxation is frequently treated my means of rest, physical therapy, steroid injections, and in severe cases of pain and dysfunction by means of surgical intervention. Due to the important vascular structures located posterior to the SCJ, surgery is seldom required. If surgery is required, classically the operation of choice is excision of the middle third of the clavicle. However, few cases have used reconstruction as a means of a SCJ corrective procedure. **Conclusions:** Seventeen months following the initial injury and 3 months post-surgery the patient is progressing well and anticipating a return to rescue diving. Conservative management is beneficial for those patients presenting with classic pathology. However, when patients have exhausted conservative treatments surgical options may need to be explored. The traditional surgical method of medial clavicle excision alone has variable results. This innovative approach of reconstructing the SCJ with an autograph more closely recreates native anatomy, thus allowing the patient to return to their full occupation and leisure/athletic activities.

Os Acromiale in a Collegiate Basketball Player: A Case Report

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Background: A 20 year-old male collegiate basketball player sustained an injury to his dominant left shoulder during an away game. While dribbling through the lane, he collided with an opposing player and immediately fell to the court in extreme pain. An initial evaluation by the certified athletic trainer revealed point tenderness over the acromioclavicular and glenohumeral joints and difficulty with all muscle testing due to pain. Paresthesia down the left upper extremity was noted and his range of motion (ROM) was limited due to pain. Special tests were inconclusive as generalized pain and discomfort were present. The athlete was then examined by the opposing team's orthopedist who diagnosed the injury as a rotator cuff contusion. **Differential Diagnosis**: Acromioclavicular separation, rotator cuff contusion, rotator cuff strain, labral tear, glenohumeral subluxation. **Treatment**: Early treatment had limited results and functionally he was ineffective due to significant pain with activity. However, the athlete had a great desire to return to play. Initial x-rays one week post injury were negative but functional improvements were minimal. The orthopedist ordered a magnetic resonance imaging (MRI) which then revealed an os acromiale injury. Surgery was delayed to consult with experts regarding this type of injury. Nine weeks post diagnosis, an open reduction internal fixation (ORIF) was performed using a calcium bone graft and two cannulated screws. Acute post surgical management consisted of ice, pain medication, and a limited ROM brace. Early treatment and rehabilitation focused on passive ROMbelow 90°. Ten days post surgery the athlete began riding a stationary bike and lower body weight lifting. One month follow-up an x-ray revealed good bone healing, prompting the orthopedist to discontinue the athletes' use of the brace. He began using tubing below 90° and continued with cardio and lower body lifting. Rapid gains were noted and heprogressed to overhead rehabilitation activity. Rehabilitation stressed resistance tubing, light weight training, and scapular stabilizer strengthening. The athlete had full ROM 2 ½ months post surgery, prompting the orthopedist to allow some basketball activity. Four months post surgery he passed all ROM and functional testing and was cleared for full basketball activity, and at six months was granted his full release.

Non-Surgical Management and Rehabilitation of Labral Tears in Division III Overhead Athletes: Clinical Case Series

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Background: Four individual cases of overhead athletes at a Division III institution presented with shoulder pain. *Case 1:* Twenty year old volleyball player complained of dominant shoulder pain with overhead activity in April 2011. History of partial biceps tendon tear in 2007 and treated with cortisone injection. No complications until 2011 spring season. No history of dislocation or subluxation. Significant pain, clicking, and popping in anterior shoulder with

overhead activity, Positive Empty Can, Full Can, O'Brien's, and Neer tests. *Case 2:* Twenty-one year old baseball pitcher presented with dominant anterior shoulder pain in August 2011 with overhead activity and activities of daily living. History of dislocation with spontaneous reduction in December 2010.Threw 6 innings during 2011 season with mild discomfort. Did not participate in baseball during Summer 2011. Presented with general shoulder weakness secondary to pain and positive Apprehension test. *Case 3:* Nineteen year old baseball pitcher reported traumatic fall with anterior and lateral shoulder pain in August 2011. Pain with throwing more than sixty feet, positive Empty Can and Hawkins test for pain. *Case 4:*Nineteen year old softball catcher suffered a non-dominant glenohumeral subluxation in April 2010. She reported back in Fall 2010, after working with a physical therapist at home, with no pain and was cleared for full participation. February 2011, patient subluxed again after falling. Positive Posterior Labrum, Impingement, and Apprehension tests. Variety of MRI and physician confirmed glenohumerallabral tears in dominant and non-dominant shoulders. **Treatment:** All athletes opted for conservative management. Rehabilitation was completed with a physical therapist and certified athletic trainers five to six days a week. Patients were restricted to no overhead motion for the first three to four weeks of rehabilitation. Throwing progressions were implemented at two and half to three months after beginning the rehabilitation program. All patients were re-evaluated on a weekly basis. The goals of the first phase of rehab included reducing pain, increasing range of motion, and regaining neuromuscular control of serratus anterior and lower trapezius muscles and lasted three to five days. Exercises included scaption, Ts and Ys and sidelying external rotation progressing from body weight to five pounds. Phase two lasted one to two weeks. The goals of this phase included increasing strength and proprioception. Exercises included D1 and D2 flexion/extension patterns, internal and external rotation, perturbations, push up plus, and isometric strength. The goals of phase three included increasing endurance and progressing back to sport specific activity; phase lasted two weeks until return to play. Exercises included plyometrics and eccentric external rotation with resistance. **Results:** The complete rehabilitation and throwing progression programs were completed successfully by all patients in three and a half to four months. **Uniqueness:** The uniqueness of these four cases lies in the fact that they were all athletes playing overhead sports with confirmed glenohumerallabral tears. All four chose conservative treatment, and were all able to continue to participate at a high level of competition with minimal pain and setbacks. **Conclusions:** The diagnosis of labral tears is commonly regarded as a necessary surgical repair if full return to play is anticipated. These cases indicate that proper conservative care, with adequate time for progressions, can allow an athlete to return to play without surgery, and still return to pre-injury functional status.

Acute Traumatic Multi-joint Injuries in a Division I Female Soccer Athlete

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Background: An 18 year old Division I female soccer forward with no previous history of injury to her left side collided with a goalie during game play. Athlete was unable to report a detailed mechanism of injury(MOI). The athlete presented to the athletic trainer complaining of pain from her left knee to her left ankle with immediate moderate swelling and no associated discoloration or deformity. Palpation revealed severetenderness along all medial knee structures, lateral knee structures, patellar tendon, medial and lateral hamstring tendons, in the popliteal fossa, along the tibia, fibula, and the bilateral ankle ligaments. Neurological symptoms such as tingling and mild numbness were also reported that radiated into the foot and toes. Neurologic symptoms subsided after approximately 10minutes. She was placed in an immobilizer and was non-weight bearing (NWB). **Differential Diagnosis:** Grade II medial collateral ligament (MCL) sprain, patellar subluxation, proximal tibia fracture, medial ankle sprain, lateral ankle sprain, fibular head fracture with associated Peroneal Nerve involvement. **Treatment:** Athlete received an MRI which revealed a compression fracture of the anterior medial tibial plateau, near complete tear of the MCL, and increased signal in the posterior cruciate ligament (PCL). Radiographic exam of the ankle revealed no fractures. Athlete was NWB for four weeks and engaged in a rehabilitation program to decrease pain and swelling and increase range of motion at the knee and ankle. At five weeks post injury substantial improve-ments have been observed. Pain has decreased from 9/10 to 1/10 in the knee and ankle, and active range of motion for knee flexion has increased to 120°. Two weeks of immobilization resulted in left side atrophy, which has been resolved with isometric and isotonic exercises. The ankle sprain has recovered to a fully functional level. **Uniqueness:** This athlete sustained substantial injuries to the knee and ankle joints as a result of one MOI. Typically, high forces and velocities, such as those in a motor vehicle accident, cause these types of injuries but this mechanism displayed fairly low forces and velocities in comparison. The presentation of the injury is also unique due to the pain pattern and remarkable sensitivity to palpation of the entire lower leg. Due to the unique presentation of these injuries, radiographic imaging was required to confirm the extent of the injuries sustained in the knee and ankle. Based on the diagnosis of an MCL sprain, it is assumed that a valgus force was applied to the knee. In addition, it can be assumed that there was an associated rotational mechanism that

caused the compression of the femur on the tibia and subsequently the anterior medial tibial plateau fracture. It is interesting to note that the anterior cruciate ligament (ACL) was not damaged with the rotational mechanism, as this is the most common mechanism of an ACL sprain. **Conclusions:** It is possible for multi-joint injuries to occur in an athletic environment as a result of one MOI. Athletic movements are by nature multiplanar, and subsequently athletes are at risk for sustaining multiple injuries as a result of one mechanism. A comprehensive examination that includes radiographic imaging is necessary to rule out differential diagnoses, and should include the joints above and below the injury site so that an accurate diagnosis can be reached.

Knee Pain in Collegiate Football Player

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Background: A 22 year old male defensive end reported sharp anteromedial left knee pain upon making a tackle during a game. Visual inspection during the on-site evaluation revealed a lateral patellar dislocation. The team physician relocated the patella on the field. The patient was placed in a functional patellar stabilization brace, and was cleared to return to competition. Upon returning to the game, the patient demonstrated a positive antalgic gait. He limped off the field complaining of severe knee pain. A second examination on the sideline revealed positive edema and ecchymosis, medial joint tenderness, and limited active ROM. Valgus stress test was negative at 0°; however, at 30° a positive test elicited a soft end feel. The patellar apprehension and glide tests were positive for patellar instability. The patient's medical history was not significant for traumatic injuries to the involved knee or surrounding area. **Differential Diagnosis:** patellar dislocation, patellar instability, patellar fracture, patellar tendon tear, medial patello-femoral ligament sprain, osteo-chondral lesion, femoral osteo-condylar contusion, medial mensical tear, and medial collateral ligament sprain. **Treatment:** The patient was iced, elevated, wrapped with a compression bandage, placed into a straight leg knee immobilizer, instructed to ambulate utilizing non-weight bearing crutch gait pattern, and diagnosed with a patellar dislocation and medial collateral ligament sprain by the team orthopedic surgeon. An MRI was ordered. The results indicated a lateral patellar dislocation, anterolateral distal femoral contusion with no osteochondral lesion of the patella, and a grade III medial patellofemoral ligament (MPFL) sprain. The patient was placed on a rehabilitation program prior to surgery consisting of thermal agents, ROM exercises, and massage to reduce pain and edema. Status post two weeks the patient underwent MPFL recon-struction. During surgery, a patellar bone fragment was discovered within the edema and removed. The initial post-operative rehabilitation program consisted of wound management, use of a rehabilitative patellar stabilization brace, electrotherapy, and therapeutic exercise program to decrease pain and edema, and increase neuromuscular coordination, proprioception and range of motion. Four weeks post-reconstruction, a more aggressive rehabilitation program was imple-mented to further improve proprioception and range of motion and restore muscular strength, endurance, and power. Thirteen weeks post-reconstruction, the patient progressed to jogging on a treadmill to restore cardiovascular endurance. Sixteen weeks post-reconstruction, the patient was functionally stable and was prescribed sport-specific activities that included team conditioning drills to restore speed, agility, and power. The patient was cleared by the team physician and fully returned to athletic activities approximately 24 weeks post-reconstruction. His return to activity did not elicit any pain or apprehension. **Uniqueness:** MPFL ruptures in conjunction with medial collateral ligament pathologies are unique in athletics. Specifically, in this case, the injury was difficult to diagnose on initial evaluation because the reported symptoms and obvious deformity overshadowed the ligamentous involvement. Furthermore**,** the MRI did not reveal the displaced fragment of the patella, which would indicate the requirement of surgical intervention. **Conclusion:** Patellofemoral injuries are a common knee pathology and can affect prepubescent children through adults. The MPFL secures the patella to the medial aspect of the knee and is frequently injured as a result of a lateral subluxation. Predisposing factors relevant to this case included hypermobility caused by hamstring and iliotibial band tightness. Prompt recognition and management of acute patellofemoral pathologies are crucial for reducing further stress on other joint structures. Tearing of the MPFL can lead to decreased mechanical knee extensor mechanism efficiency, degrading of the femoral and patellar articular surfaces, and mechanical and anatomical instabilities. Surgical intervention reduces the risk of recurrence by over 30% and is usually indicated to diminish joint pathomechanical and functional limitations.

Isolated Capitate Fracture in a Collegiate Women's Lacrosse Player

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Background: On February 3rd 2011 a 17-year old female collegiate lacrosse player tripped over a teammate's foot during an indoor pre-season practice. The athlete landed on flexed knees and outstretched hands. Her momentum caused her to lacerate her chin. Wrist evaluation revealed mild non-specific tenderness (4/10) along the left distal

radioulnar joint and distal carpal bones. No tenderness upon palpation of the right wrist. Bilateral wrist flexion and extension AROM and PROM were WNL with pain (4/10). All other AROM and PROM were WNL bilaterally. MMT were 5/5 in all directions bilaterally. Radioulnar percussion and compression tests were negative bilaterally. The athlete reported a previous history of a left wrist fracture in elementary school. She was referred to the emergency room for stitches and instructed to follow up with the athletic training staff the next day. **Differential Diagnosis:** Wrist and/or hand sprain, contusion, fracture. **Treatment:** The athlete received 7 stitches in her chin. Due to her mild left wrist pain, A/P and scaphoid x-ray views were conducted and were negative. The following day she presented with mild left wrist swelling in the area of the dorsal wrist and anatomical snuff box. She was tender to palpate (5/10) along the palmar and dorsal scaphoid and lunate bones. Due to the likelihood of scaphoid fractures not being present in initial x-rays the athlete participated in daily and lacrosse activities as tolerated with soft or orthoplast splint protection. On approximately March 1st the athlete continued to complain of left wrist pain localized to the area of the scaphoid. The athlete was evaluated by the team physician and an MRI of the left wrist was ordered to rule out a scaphoid fracture. The MRI revealed a non-displaced fracture of the left capitate. She was referred to an orthopedic hand specialist. Due to insurance limitations and schedule conflicts she was unable to see the specialist until early May 2011. Evaluation revealed no point tenderness, deformity, swelling, or discoloration in the capitate. ROM and strength of the left wrist and hand were WNL. Despite the positive MRI the physician allowed the athlete to discontinue wearing the splints because pain with activity had resolved. His recommendations were: repeat the MRI in 4 weeks and avoid push-ups due to compressive forces placed on the wrist and hand. The follow up MRI indicated the capitate is fully healed. The athlete currently reports no pain and continues full participation in lacrosse. **Uniqueness:** Isolated capitate fractures are extremely rare, comprising about 1-2% of carpal fractures. They typically occur as a result of high energy trauma and are almost exclusively associated with fracture of the scaphoid waist occurring as a trans scaphoid trans capitate variant of the perilunate dislocation. This athlete had no pain in the area of the capitate. Tenderness was generalized in the early stages and later localized to the scaphoid. Initial x-rays were negative, which is uncommon in capitate fractures. Upon follow up with the specialist this athlete presented with no pain or limitations in activities of daily living or lacrosse. Capitate fractures often have poor outcomes because early diagnosis and cast immobilization are the preferred treatment. Capitate fractures are commonly unstable and delayed union, non-union, and avascular necrosis are possible complications. In this case the athlete had no complications despite late diagnosis, continued participation in lacrosse with moderate bracing and no change in activities of daily living. **Conclusions:** Wrist and hand injuries are often missed on initial imaging. This case highlights the importance of follow-up radiology when wrist pain persists. The athlete was fortunate to have such a positive outcome despite having an isolated capitate fracture.

Cervical Neuropathy in a Division I Football Player

Galeazzi BL, DiNapoli D, Cordone J, Straub SJ: Quinnipiac University, Hamden, CT; Yale University, New Haven, CT

Background: A 21 year old outside linebacker spear tackled an opposing athlete causing left lateral cervical flexion and depression of hisshoulder. The athlete was face down on field and initially had a short loss of consciousness. The athlete stated numerous times he was unable to feel his right arm. Strength assessment indicated normal strength in the left arm but on the right side the athlete was limited to grip strength in right hand. The athlete had a previous medical history of a herniated lumbar disc at L4/L5 region and also had a history of left shoulder contusion and abnormally-formed glenoid fossa. The athlete was spine boarded and transported to the local Emergency Department **Differential Diagnosis:** cervical spine fracture, cervical spine ligamentous sprain, spinal cord injury, concussion, shoulder dislocation or fracture. **Treatment:** A CT scan of brain and neck read unremarkable and thus ruling out cervical spinal injuries. The athlete had persistent deficits in his right arm (deltoids, biceps, infraspinatus) but recovered some sensation and function in fingers (5/5 finger flexors, extensors, abductors) 2 days S/P and was presumed to have suffered a brachial plexus injury. The athlete spent a week in the hospital for continued neurology consultations. The athlete was discharged when medically stable and cleared by radiology with close outpatient follow up. The final diagnosis was a right brachial plexus injury, specifically a C5 nerve root avulsion and a partial C6 nerve root avulsion. The initial treatment plan called foredema reduction and occupational/physical therapy. Medications were prescribed for pain and causalgia. The subsequent four month period showed minimal recovery. The patient was informed of surgical options and risks and ultimately consented to surgery. The pre-surgical plan was for a right supraclavicular exploration of C5-6 with inoperative testing. The plan included nerve grafting within the shoulder; axillary nerve, through posterior division upper trunk and suprascapular nerve with ulnar and sural nerve grafts from either one or both legs as necessary. Surgery was performed at approximately 5 months status-post. The actual reconstruction consisted of a sural nerve graft that ran from the C5 nerve root to supra-spinatus nerve and to posterior division of upper trunk of the right brachial

plexus and a double Oberlin's procedure. It was estimated that over the next 2 years, the athlete would regain useful shoulder stability and elbow flexion. At follow-up appointment 5 months S/P reconstructive surgery, EMG indicated minor reinnervation to the supraspinatus and no reinnervation to deltoid or elbow flexors. He also demonstrated nearly full antigravity elbow flexion and mild gravity eliminated external rotation of shoulder. The patient did demonstrate anti-gravity elbow flexion with shoulder internally rotated. Gravity eliminated position was full with a smooth arc of motion. Numbness and pain were still present. The patient was referred to hand therapy to assist with functional activities. The current goal is to continue to re-educate and lift a 5 lb back pack with right hand by 14 months post injury. . **Uniqueness:** While 65% of collegiate football athletes are reported to suffer brachial plexus injuries at some point in in their careers, the more common mechanism of nerve root avulsion are motorcycle accidents. The reported incidences of brachial plexopathies with nerve root avulsions in football are limited. **Conclusions:** While brachial plexus injuries are common is football, the avulsion of a nerve root is rare. Conservative treatment options may be long due to the lengthy time period of nerve regeneration. When conservative measures fail, nerve grafting must be considered. Complete recovery may be difficult; clearly defined limited functional activities may be more appropriate long term goals.

Thoracic Pain in a Collegiate Runner

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Background: A 22 year-old female runner presented with chronic respiratory difficulty, unremitting lateral right dorsal thorax pain, finger tip pallor, and numbness in the upper extremities. Pain quotient was described as 5/10 at rest, 7/10 with inspiration, and 8/10 during and after activity. Physical examination revealed a right hump of the thoracic cage in the flexed position, palpable tenderness between ribs 3-6, sensory and motor deficits of the left lateral upper arm, and a weak radial pulse. ROM testing revealed full trunk flexion, but limited extension, left and right rotation and side bending. The patient's medical history was significant for structural scoliosis and hypermobility that was diagnosed at the age of 13 with a 36° thoracic and 33°lumbar curve. Later radiographs taken at the age of 20 revealed an increase in the thoracic (40°) and lumbar (43°) curves. Previous treatment consisted of 3½ years of rehabilitation starting at age 18 focusing on strengthening and manual therapy including mobilizations and traction to alleviate symptoms. **Differential Diagnosis:** Rheumatoid arthritis, asthma, pulmonary embolism, thoracic outlet syndrome, Raynaud's disease, and restrictive lung disease. **Treatment:** After the initial evaluation, the patient was referred to her PCP. The PCP ordered an MRI that revealed degenerative discs at C2-C3 and C5-C6, and minimal bulging at L2-L3; however, results were inconclusive to the chief complaint. The patient was referred to an orthopedic spine specialist who prescribed an NSAID, ordered blood tests which ruled out rheumatoid pathology, and referral to a pulmonologist. The pulmonologist ordered a chest x-ray and a pulmonary function test. Radiographs were unremarkable; however, the pulmonary function test revealed consistent reduction in forced vital capacity and total lung capacity implying restriction. The patient was diagnosed with restricted right lung disease and referred back to the orthopedist. Status post two months, plain film radiographs were taken and identified an increase in the thoracic (51°) with no changes to the lumbar (43°) curve. The orthopedist definitively diagnosed the patient with restrictive right lung disease, thoracic outlet syndrome, and Raynauds's disease secondary to her progressive structural scoliosis and concluded that her condition would continue to deteriorate without surgical intervention. A posterior T5-L1 interbody vertebral fusion was performed. A postoperative right lung pleural effusion developed resulting in further dyspnea. An ultrasound-guided thoracentesis removed 1.4 L of fluid. Three months postoperative pulmonary function test demonstrated an increase of 1 L in total lung capacity. Five months post-operative the patient continues to progress with full body and respiratory rehabilitation and is expected to make a full recovery. **Uniqueness:** This case is unique because the patient's increasing thoracic scoliotic curve was the underlying cause of her chronic respiratory difficulty. The progression of scoliosis characteristically discontinues when growth is completed; however, in this case further increases were due to inherent spinal instability. As the vertebral bodies involved in the scoliosis rotated, the spinous processes deviated toward the concave side of the curve, and the ribs followed the rotation of the vertebrae. This rotation placed a 30% restriction on the right lung and as the thoracic curve gradually increased, the pulmonary restriction would have as well. **Conclusions:** Restrictive lung disease is caused by a deformity of the chest wall. Changes to the thoracic cavity associated with significant scoliosis can dramatically affect respiratory function. Due to the rarity of this condition, clinicians must be aware of a patient's medical history and its potential to affect a patient's future

health. Proper evaluation, management, and intervention of scoliosis have the capacity to limit the debilitating nature of the condition to facilitate the continuation of a physically active lifestyle.

A Distal Fibula and Pilon Fracture with a Dislocated Proximal Fibular Head in a Collegiate Softball Athlete

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Background: An 18 year old female softball outfielder with a previous history of proximal fibular subluxation injured her left leg during sliding drills performed at full speed on field turf. While sliding her left, tuck, leg became lodged in the turf forcing her knee into external rotation and ankle into eversion and plantar flexion. Athlete experienced substantial pain and had an obvious deformity at the ankle with foot in eversion and protruding of the lateral malleolus. The proximal fibular deformity was obstructed by her athletic apparel .On-field evaluation revealed a possible distal fibular fracture with neurovascular status intact. Athlete had a positive squeeze test with pain proximally and distally. Athlete was extremely tender to palpate around ankle and fibular head and could not plantar or dorsiflex. The athlete's cleat was removed with shears and a vacuum splint was applied. Athlete was immediately referred to emergency department; **Differential Diagnosis:** Grade III deltoid ligament sprain, tibial plateau fracture, syndesmotic sprain, proximal fibular head dislocation, fracture of distal tibia, fracture of distal fibula. **Treatment:** Diagnostic imaging from MRIs and CT scan revealed a dislocated proximal fibular head, closed distal fibular and pilon ankle fracture, and a grade II PCL sprain. The fibular head was initially reduced and athlete was placed in a fiberglass cast for approximately two weeks to allow for swelling to decrease. A surgical ORIF was performed to stabilize the distal tibia and fibula and bone fragments were excised from the ankle joint. Athlete was placed in a fiberglass cast for three months and was non weight bearing (NWB). Upon cast removal athlete was placed in a walking boot and NWB exercises were initiated. Athlete preformed active ankle range of motion, strengthening for quadriceps and intrinsic muscles of the foot. After one week of rehabilitation the athlete began progressive resistive ankle exercises. After two weeks the athlete was able to walk without walking boot for short distances and was placed in an air cast splint. At six months status post ORIF a jogging protocol was initiated; at which point she demonstrated hip external rotation during the swing phase and engaged in gait training that includes augmented feedback during straight-ahead jogging and sport specific motions. Athlete continues to complain of substantial bone related pain when jogging. **Uniqueness:** The type of injury sustained most commonly occurs in high velocity, high force impacts such as a motor vehicle accident, and most typically involves an open fracture. This athlete sustained her injuries during participation in an athletic event with relatively low forces and velocities, and all fractures were closed. The nature of this injury has resulted in increased proximal tibiofibular and ankle mortise joint play which decreases stability at the ankle joint. Even with ORIF this athlete displays biomechanical dysfunction that needs to be addressed with functional assessments and neuromuscular rehabilitation that includes augmented feedback. **Conclusion:** It is important to recognize that playing surface can have an effect on the type and severity of injury sustained during athletic practices. When an athlete sustains a severe injury to the structures of the ankle mortise and knee, any alterations in gait biomechanics must be recognized and addressed to improve function and allow for return to play.

Giardiasis in a Female Field Hockey Player

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Background: A 19-year-old female, Division I field hockey player presented with a headache, lightheadedness, dizziness, muscle soreness, fatigue, and vomiting in mid-August. Her glands were not swollen, and her throat appeared to look normal. She had been complaining of upper quadrant pain resulting in a loss of appetite, which followed with a weight loss of about 10 pounds in approximately 2 weeks. **Differential Diagnosis:** Amoebiasis,Ascariasis, E. Coli Infection, elminthiasis, Hookworm, Salmonella Infection, Schistosoma Mansoni, Stomach Flu, and Traveler's Diarrhea. **Treatment:** The team physician was present in the athletic training room during the initial evaluation. After splenomegaly was ruled out, blood tests were ordered including a complete blood count (CBC) differential, electrolytes, blood urea nitrogen (BUN), and creatinine. The athlete was given an IV of Phenergan and Zantac 50 mg to help with her stomachache, but she had an allergic reaction to the Phenergan. She was then given an IV of Benadryl, which helped to decrease her symptoms after an hour. When the athlete was feeling well enough to return home, her mother picked her up; however, on their way home the athlete began having symptoms again, so she was rushed to the emergency room. At the emergency room, all tests came back normal and a stomach ulcer was ruled out. Her personal physician ordered an endoscopy that showed no inflammation or other abnormalities. A stool sample was subsequently ordered, which determined that the athlete had giardiasis. She was treated with a class of anti-biotics called Nitroimidazole. Metronidazole is the most commonly used antibiotic in this class. Metronidazole enters the parasite cell and becomes active. Once active, the antibiotic results in cell death.

Uniqueness: Giardiasis is common in people who travel to undeveloped or developing countries due to poor sanitation. Drinking unpurified water from streams or lakes, eating uncooked or unpeeled fruits and vegetables, and improper hand washing techniques can lead to infection. Any water that is possibly contaminated should be boiled before consumption. Individuals should use bottled water for activities such as tooth brushing, making ice, and cleaning food. Antibiotics cannot prevent giardiasis or other intestinal infections, but is recommended at the onset of symptoms. Giardiasis may create challenges for treatment in pregnant women because there is no optimal combination of therapeutic agents. The patient was unaware of drinking any contaminated water and had not traveled to any countries where contaminated water would be an issue. Her immune system may have been weakened due to a case of mononucleosis that she experienced 3 to 4 months prior to this incident. **Conclusions:** Giardiasis is a rare disease that can be mistaken for many other intestinal pathologies. When traveling, especially to undeveloped countries, extreme caution should be taken when consuming water and food. Proper hygiene should be maintained to decrease the chance of contracting the parasite *G. Lamblia*. After onset of symptoms, the patient should be concerned about hydration and electrolyte balances. Individuals diagnosed with giardiasis should refrain from attending work or school to prevent the spread of infection. Severe cases require hospitalization, mainly due to dehydration. Athletic trainers should be aware of rare conditions like giardiasis because it can lead to malabsorption, dehydration, and weight loss. It is important to maintain proper hygiene techniques to limit the possibility of spreading the parasite.

The Role of Foot Core Training in a Recalcitrant Foot and Ankle Condition

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Background: Patient was a 32 year old male recreational basketball player. He rolled his ankle while landing on another player's foot during a basketball game in September 2009. He saw a physician on 01/26/10 complaining of pain at the base of the 5th metatarsal from the initial injury in September. The physician prescribed crutches and referred him to sports medicine. He saw the sports medicine physician on 02/02/10 where he was diagnosed with peroneal tendinopathy and plantar fasciitis. He was prescribed rehabilitation to work on dynamic ankle stabilization exercises. The patient's conditionwas recalcitrant and he sought out another physician on 06/11/10. The physician diagnosed him with an ankle sprain and secondary plantar fasciitis and prescribed 3 weeks of non-weightbearing with ankle and foot immobilization. Upon evaluation on 07/02/10, the patient was removed from the immobilization and prescribed home exercises and meloxicam. Again, the patient's condition did not improve andhe saw another physician on 09/08/10 who, based on evaluation and diagnosis, ordered an MRI and prescribed an air splint. The MRI revealed posterior tibialis tendinopathy, mild tendinopathy involving the flexor tendons and peroneal tendons, plantar fasciitis, osteochondral lesion of the lateral talar dome, and joint effusion involving the tibiotalar and subtalar joints. On 09/29/10, the patient was diagnosed with tibialis posterior tendon dysfunction. **Differential Diagnosis:** Plantar fasciitis, peroneal tendinopathy, lateral ankle sprain, tibialis posterior tendon dysfunction **Treatment:** The patient was prescribed a walking boot, crutches, and strengthening exercises for 4 weeks following the MRI. Upon follow-up evaluation on 10/27/10, he was prescribed a foot orthotic, ankle stirrup, and advanced his strengthening exercises. Upon follow-up evaluationon 01/12/11 the physician noted that the patient was unable to perform a single-leg heel raise. At the follow-up evaluationon 03/09/11, the patient could complete a single-leg heel raise to 1 inch from the floor and was told to progress his strengthening exercises. Upon follow-up evaluationon 05/04/11, the physician stated that the patient could initiate the single-leg heel raise, but could not perform the full heel raise. In August 2011, the patient sought out treatment from an AT at the middle school where he coached. The AT noticed deficits in the patient's intrinsic foot muscles (foot core) and prescribed short foot exercises. Short foot exercises are a unique treatment that involves activating the foot core to increase the medial longitudinal archby narrowing or shortening of the foot while the toes remain relaxed. The exercises begin with a modeling of the medial longitudinal arch and progress to tightening the arch while walking and running. Each week, the patient completed the Foot and Ankle Ability Measure Activities of Daily Living (FAAM ADL) and FAAM sport along with his level of pain. After 5 weeks of foot core exercises, the patient showed improvement in pain levels and overall function (Week 3: FAAM ADL=61%, FAAM sport=21%, pain=5/10, ADL function=84%, Sport function=70%, function=abnormal; Week 4:FAAM ADL=71%, FAAM sport=21%, pain=4/10, ADL function =87%, sport function=70%, function =nearly normal; Week 5: FAAM ADL=73%, FAAM sport=50%, pain= 0/10, ADL function=88%, sport function=77%, function=nearly normal). Upon follow-up evaluation on 09/21/11, the physician stated that the patient could perform a full single leg heel raise and was released from the physician's care. **Uniqueness:**The patient had minor improvements when performing standard rehabilitation. With the supplementation of the short foot exercises, he was able to progress

more rapidly and vastly.The addition of foot core training increased his daily and functional sport outcomes as well as decreased his level of pain. **Conclusions:** Foot core training can be an effective supplementary intervention to traditional home exercises programs when treating tibialis posterior tendon dysfunction.

Isolated Fibular Avulsion Fracture in Female Basketball Player

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Background: An 18 year old female basketball player reported to the orthopedic clinic with right knee pain. The athlete was non-weight bearing (NWB) with the use of crutches. Two days prior, the athlete described a hyperextension injury while coming down from a rebound. She presents with lateral knee pain which was tenderness to palpation, slight knee effusion and loss of range of motion due to pain. She has no joint line tenderness. On physical evaluation, Lachman's test, anterior drawer, Apley's compression test, and valgus stress test were all negative. The only test that elicited pain was hyperextension with a varus stress load. Radiographs were ordered and reviewed. **Differential Diagnosis:** Possible injuries include fibular collateral ligament sprain, hamstring tendon strain, lateral meniscus tear, posterior cruciate ligament rupture, posterior lateral corner tear and fibular head fracture. **Treatment:** The radiographs showed a minimally displaced, fibular styloid fracture of the right knee. The patient was placed in a knee immobilizer, locked at 30 degrees of flexion. She was instructed to remain NWB, ice for 20 minutes three times a day, and report back to the clinic in two days. An MRI was ordered to rule out further soft tissue internal derangement, including a posterolateral corner injury. The MRI results indicated an avulsion fracture of the fibular styloid process at the fabellofibular ligament insertion. All other anatomical structures including the cruciate ligaments, collateral ligaments and menisci, as well as the lateral ligamentous complex (biceps femoris tendon, popliteus tendon and popliteal fibular ligament) were intact and within normal limits. The patient continued with a conservative treatment plan of immobilization and returned to the clinic two weeks later for repeat radiographs. The repeat images showed no further displacement of the avulsion fracture and slight increased density in the area of the fracture indicating a healing response. The athlete progressed to full weight bearing within the brace and began physical therapy (PT) four weeks after the initial injury. Two weeks later, the athlete reported back to the clinic with no tenderness over the proximal fibular head. She had begun ambulating without pain and has progressed well in PT. She had no complaints of instability. She was then placed in a neoprene hinged sleeve and told to continue with PT. The athlete was able to return to full activity within 6 weeks without any complications. **Uniqueness:** In this case, the athlete sustained a fibular avulsion fracture which is typically indicative further soft tissue impairment. Both the clinical exam and the MRI showed that the avulsion fracture was isolated with no other internal derangement.**Conclusions:** Hyperextension knee injuries commonly cause a variety of ligamentous and meniscal damage. Due to the sole injury to fibular head, return to play was possible within a month and a half. It is important to follow the clinical exam as well as image results so that a proper treatment plan can decrease the time out of activity.

Bilateral Tri-Compartment Exercise Induced Compartment Syndrome in a Collegiate Distance Runner: A Case Report

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Background: We present a case of a collegiate female distance runner who developed compartment syndrome bilaterally in her anterior, lateral, and deep posterior compartments. An 18 year old female collegiate distance-runner with no prior history of lower leg injury progressively developed traditional symptoms of lower leg exercise induced compartment syndrome (EICS). These symptoms worsened over the course of approximately seven months from the end of her freshman Outdoor Track season to the beginning of her sophomore Indoor Track season. The patient was very conscious of the guidelines for changing training shoes every 300-500 miles and remained in the same model shoe when purchasing new ones. She was very attentive to making sure her training contained a consistent variety of hills, running on both sides of the road, pavement and trail mileage, and followed the normal training progression in workout types. The patient claimed to have been running about 30 miles per week as a senior in high school, which progressed to about 50 miles per week during her freshman year of cross-country and continued throughout the Indoor and Outdoor track seasons. It was at this point that she began to notice some tightness and sharp pain posteriorly in her lower leg. The pain gradually increased and spread to other compartments within both lower legs until the patient could no longer tolerate the pain during training. The symptoms progressed to the common compartment syndrome symptoms of pressure sensation, increased pain with activity, and eventually peripheral neurological symptoms. The patient was referred to a physician who diagnosed her with bilateral compartment syndrome using a slit catheter technique. **Differential Diagnosis:** Medial tibial stress

syndrome, tibial or fibular stress fracture, lower leg muscle strain, deep vein thrombosis. **Treatment:** The patient was initially instructed to decrease training volume and was managed with conservative treatment including heat and stretching prior to training and cryotherapy afterwards. Myofascial release techniques were also performed. The symptoms eventually limited the patient to pool-running, biking, and elliptical training. Due to the severity of the symptoms and poor results of conservative treatment, a single incision fasciotomy was performed to reduce compartment pressure approximately one month following diagnosis. The patient was non-weight bearing with the use of a wheelchair initially for three days following surgery. She progressed to full weight bearing and began a rehabilitation program for range of motion and strength. The patient slowly returned to running approximately two months after surgery however she was instructed to stay on soft grass surfaces and utilizing the treadmill to avoid excessive impact stress. At seven months post-surgery, the athlete was fully participating in cross-country and at this time has not reported any symptoms related to EICS. **Uniqueness:** Of the usual distance runner overuse injuries, exercise induced compartment syndrome (EICS) is one of the more uncommon. The involvement of three compartments is even more uncommon. This is usually a result of trauma. **Conclusion:** Although many distance-running coaches increase training volume conservatively by season, they should also be aware of the volume's overall progression over the course of multiple seasons. Athletic trainers should also become progressively more investigative as conservative treatments fail and look toward ruling out more serious conditions such as EICS as the signs and symptoms spread further throughout the lower leg. This case should also serve as an article of awareness to coaches and clinicians of rarer overuse injuries such as EICS.

A Recalcitrant Skin Lesion and Subsequent Infection in a Recreational Intramural Male Athlete: A Case Report

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Background: A 35 year old recreational intramural male athlete presented to the athletic training medical staff in late Fall 2010 with an insidious skin lesion of unknown origin on his right lateral malleolus. There was no apparent mechanism of injury or trauma to the area that the patient could recall. Prior pertinent medical history revealed a skin lesion seven years prior on his left lower leg, however, based on the patient's description, this lesion presented differently. The patient appeared healthy, in good physical condition, and reported no other relevant health issues or conditions. The patient reported the lesion to be itchy and slightly painful to the touch as well as his ankle feeling "swollen". Upon inspection by the athletic trainer the examination revealed a 4.5cm x 2.2cm lesion over the right lateral malleolus. Diffuse swelling as well as signs of an active infection were noted in the entirety of the ankle. No other scars or markings were noted in the area. The lesion itself was flat, warm to the touch and crusted over with areas of desqamatous skin along with purulent drainage. There was no detectable odor. A bacterial infection was suspected at this time and due to the size and active appearance, the lesion was protected from the environment with a protective covering and the patient was referred to his primary care physician for further evaluation. **Differential Diagnosis:** Bacterial infection (methicillin resistant staphylococcus aureus), insect bite (several types), diabetes mellitus (types I and II), squamous cell carcinoma, xerosis, eczema, leprosy, psoriasis, contact dermatitis, atopic dermatitis, seborrheic dermatitis, ceramide deficiency. **Treatment:** The athlete initially was placed on oral Cefalexin (Keflex) 250mg three times per day for 10 days along with Mupirocin 2% topical ointment; however on day 6 the patient returned to the athletic training staff inquiring about the lesion. It was noted the lesion had increased to 8.5cm x 6cm although signs of active infection seemed to be controlled. Due to the nature of the lesion, the patient's primary care physician was alerted and a referral to a dermatologist was made. The oral Cefalexin was continued, but the Mupirocin ointment was discontinued as it was felt to have irritated the lesion. Inspection by the dermatologist confirmed a bacterial infection, but the etiology of the lesion was endemic to the patient; he was diagnosed with a ceramide deficiency which caused the itching and scaling. Because the patient scratched the area a secondary infection was created. The patient was instructed to take note of any signs of further infection and begin a course of using Ceravé™ topical cream three times daily to help moisturize and replace the deficient ceramides. Clobetasol propionate 5% also was used twice daily to limit the inflammation. Additionally, the patient was instructed to partake in a diet rich in healthy oils such as omega-3s and olive oil. Upon initiating this new course of treatment the patient's symptoms resolved and no further lesions were noted at a three- and six-month follow-up. **Uniqueness:** Skin disorders are common in athletes; however, this form of an autoimmune ceramide deficiency is relatively uncommon in healthy athletic populations. **Conclusions:** Ceramides are a family of lipid molecules that serve diverse functions in the skin including maintenance of cell walls. Occasionally, some people fail to produce enough of these substances leading to skin irritation and subsequent lesions. Athletic trainers need to be well-versed in not just apparent causes of skin ailments such as the active infection in this case, but also the root causes of skin pathologies.

Type I Complex Regional Pain Syndrome: Reflex Sympathetic Dystrophy in a Female Collegiate Soccer Player

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Background: An 18-year-old female collegiate soccer player reported to the athletic training room complaining of intense ankle pain (pain scale 8/10), 6 weeks after suffering from an avulsion fracture of the right lateral malleolus. Physical findings from the athletic trainer's examination were negative for the existence of a new injury that would account for the athlete's pain so the athlete was referred to the team podiatrist for x-rays and reevaluation of the initial injury. The results of the x-rays were negative and further evaluation by the podiatrist coincided with the athletic trainer's insignificant findings. The athlete was diagnosed with overuse due to early return to play and issued conservative treatment of rest, ice, and prescription naproxen as a pain medication. Over the next 3-4 weeks, the athlete began experiencing hyper-sensitivity to touch (allodynia) and ice, atrophy of the gastroc-soleus complex, paresthesia in the fourth and fifth toes of the right foot, and a palpable skin temperature difference between the right and left lower extremities. At this time, the athletic trainer recognized the potential signs of Reflex Sympathetic Dystrophy (RSD) and referred the athlete for further consult by the podiatrist and a sports medicine physician. **Differential Diagnosis:** Anterior compartment syndrome, occult fracture, deep vein thrombosis, erythromelalgia (Mitchell's Disease), Raynaud's phenomenon. **Treatment:** Initial treatment included a bone scan that resulted in minimal abnormalities that did not confirm the RSD diagnosis. Upon consult with a panel of specialists (anesthesiologists, orthopedic surgeons, podiatrists and other healthcare providers), RSD was concluded as the diagnosis. Sub-sequent treatment included pain medication (Nortriptyline, Gabapentin, Ultram, and Zanaflex) and instruction to ease back into play at the discretion of the athletic trainer. The patient partici-pated in a rigorous rehabilitation protocol with the athletic trainer that included treadmill running, ankle ROM, calf strengthen-ing exercises, and high repetition repetitive exercises such as jumping and bounding. Rehab also included the use of rough fabric to desensitize the area. The patient was returned to full activity 9 months following the initial diagnosis of the avulsion fracture. To date the athlete still experiences sensitivity to cold and touch, atrophy of the right gastroc-soleus muscle, numbness and tingling of the fourth and fifth digits in the right foot, and a palpable temperature difference between the right and left lower extremities. **Uniqueness:** The incidence rate of RSD is approxi-mately 26 people per 100,000 annually. Although RSD can occur at any age, the median age of onset is between 46-51 years. The signs and symptoms often mimic other condi-tions so RSD is often misdiagnosed until it is in the late stages. Typically the pain of RSD coincides with an injury. In this case, the athlete did not present with RSD signs and symptoms until 6 weeks post the initial injury. The early detection of RSD by the athletic trainer led to an early diagnosis that slowed the progression of the condition and allowed the athlete to receive the treatment needed for recovery. **Conclusions:** Type I Complex Regional Pain Syndrome (also known as RSD) is a chronic pain syndrome that can occur in any one of any age following an injury or surgical procedure. The signs and symptoms of RSD can mimic the clinical features of many different injuries and can vary from patient to patient. There are no gold standard diagnostic criteria or tests that have been validated for the diagnosis of RSD. Therefore, athletic trainers must recognize that the cardinal sign of RSD is chronic pain that is disproportionately increased in comparison to the severity of an injury so early detection, immediate referral, and proper treatment of RSD can be provided.

Cavernous Malformation in a Minor League Baseball Athlete

Felton SD, Pearson BP, Galamay J, Riera P: Florida Gulf Coast University, Fort Myers, FL; Boston Red Sox, Fort Myers, FL

Background: A 19 year-old male minor league baseball athlete reported to the Athletic Training Room complaining of numbness and tingling in his right hand extending distally through his digits. Athlete had prior history of right shoulder labrum surgery, so when referred to the Team Physician for evaluation, it was believed athlete was experiencing some associated neurological pain from re-acclimatization of the shoulder to throwing. Three days following the physician exam, athlete reported back to the Athletic Trainer complaining of increased neurological signs and symptoms, notably, he stated that the morning prior to practice he was feeling heaviness in his right leg, then during practice athlete noted total right sided heaviness. Athletic Trainer, in consultation with Team Physician, referred athlete to a Neurologist for continued follow-up. **Differential Diagnosis:** Ulnar Neuritis, Brachial Plexus Injury, Shoulder Strain, Thoracic Outlet Syndrome, Cervical Disc Pathology. **Treatment:** Neurologist ordered an MRI which revealed a mass, a Cavernous Malformation, adjacent to the brainstem. It was noted that the mass was a small bleed and was responsible for symptoms that athlete was experiencing. At the time, the Neurologist suggested that the risks of surgery outweighed the benefits, and the likelihood of the athlete experiencing another bleed was less that 20%. The plan was to monitor athlete and slowly return him to participation. Athlete was held from practice the next day and within 24 hours of the examination by the Neurologist; the athlete once again began to experience increased signs and symptoms. Symptoms included left ear hearing loss, blurriness and loss of vision of his left eye. Athlete began to develop a facial droop and lost

motor function of his right leg. During Neurologist follow-up, it was decided surgery had to be performed to remove the Cavernous Malformation due to the escalation of signs and symptoms. Prior to the surgery, follow-up MRI and CT scan were performed to define exact location of the Cavernous Malfor-mation, in relation to the bleeding cavity, and the proximity of the lesion to the brainstem. It was decided the safest route for surgery was through the middle cerebellar peduncle. In this case, the Cavernous Malformation was resected com-pletely, as indicated by post-operative MRI. Athlete began in-patient rehabilitation immediately post-operatively. Athlete began to relearn activities of daily living. Within two weeks of the surgery, athlete was able to walk utilizing a walker and continue to work on walking without assistance. 4 weeks post-surgery, athlete was walking without assistance and by 5 weeks post-surgery, he began to jog with assistance. After 10 weeks of rehabilitation at the neurological rehabilitation hospital, athlete rejoined the athletic training staff at the team's training complex and began to work on baseball specific skills. Athlete returned to live pitching 16 months following surgery. Athlete continues to progress well and is slated for full return to 2012 spring training. **Uniqueness:** Cavernous Mal-formations are among the rarest forms of intracranial vascular malformations. In fact, this condition affects approximately 0.5% of the worldwide population. If these lesions begin to bleed, they can cause severe functional disturbances or death; therefore, successful recognition and manage-ment of the lesion is imperative. **Conclusions:** This case highlights the diagnosis of an athlete with Cavernous Malformation and the subsequent successful treatment. This condition and other unique diseases are conditions that athletic trainers should be aware of; however, it is not expected that athletic trainers are experts with every rare medical condition. It is important for athletic trainers to recognize signs and symptoms of conditions that are not seen daily in the athletic training room and be able to make the appropriate referral to diagnose the condition and ensure successful outcomes.

Patella Fracture in a Collegiate Football Player

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AG: University of Virginia, Charlottesville, VA

Background: A 20 year-old African-American male wide receiver presented with a right knee effusion and no known mechanism of injury. He had been participating fully in spring football activities. The patient had a past medical history of left knee medial menisectomy 18 months prior without complications. Subjectively, he complained of right knee "tightness" secondary to effusion, and discomfort around the patella while running. The patella was ballotable and not tender to palpation. There was no joint line tenderness, crepitus, or mechanical symptoms. Clinical exam revealed full active range of motion (ROM) and 5/5 strength with resisted knee flexion and extension. Ligamentous exam demon-strated a stable knee and McMurray's exam was negative. **Differential Diagnosis:** Chondral defect, meniscal injury, patella fracture. **Treatment:** The patient was referred to an orthopedist for evaluation, who confirmed the previous exam. X-rays revealed a chronic, displaced, comminuted, transverse patella fracture. The patient was noted to have an unusually long patella with alta positioning. Due to the bony displacement, this fracture was treated with an open reduction internal fixation (ORIF) using 2 longitudinal cannulated screws plus fiberwire tension band, and 1 oblique screw. The fibrous tissue between the fragments was removed and bone grafting performed. The length of the patella and comminuted nature of the fracture made successful fixation difficult. Following surgery, the patient wore a knee immobilizer locked in extension for 12 weeks except during rehabil-itation. His weight-bearing status progressed from non-weight bearing (NWB) (2 weeks), to 50% (7 weeks), to full (3 weeks in immobi-lizer). ROM was initiated gradually after 2 weeks and progressed over the next 10 weeks. At 6 weeks post-op, the patient's active ROM was 0-65° and ultimately 130° of flexion. NWB lower extremity strengthening was initiated 2 weeks post-op and progressed within ROM and weight bearing restrictions. Serial x-rays and a CT scan showed that despite prolonged post-operative restrictions, the patient had a non-union. Despite this, his pain was well controlled and he could begin running 4 months post-op. The patient progressed to football specific agility drills before experiencing hardware failure with fracture displacement 5 months post-op. The patient underwent a second surgery for ORIF revision of the patella, bone grafting, partial excision of the patella fragments with advancement of the patellar tendon and repair through longitudinal drill holes. The fracture fixation was more complex, involving 2 K-wires, a Luque wire, and a screw through the proximal tibia to serve as an anchor point for figure 8 tensioning of the patella. He is still early in the process of rehabilitation but is regaining motion as expected. **Uniqueness:** Patella stress fractures are rare. This condition has been described in several groups, including: adolescent athletes, patients with cerebral palsy, patients who have had ACL reconstruction using bone-patellar tendon-bone grafting, and patients with patella resurfacing during total knee arthroplasty. Patella fractures are typically described as a result of a direct blow, or associated with rupture of the patella retinaculum following a sudden, violent quadriceps con-traction. This case describes an older athlete with no known mechanism of injury or prodromal symptoms. The fibrous non-union presented a challenge to successful outcome. **Conclusions:** This case presents the recognition and treatment of a patella

stress fracture in a patient with no acute mechanism of injury or prodromal symptoms. Although infrequent, patella stress fractures should be included in the differential diagnosis of knee injury. Rehabilitation of this injury presents a challenge to clinicians in terms of regaining flexion post-operatively while allowing appropriate healing of the fracture site.

Gastrointestinal Pain in a Division 1 Rugby Athlete

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Background: 20 YO, female Division 1 collegiate rugby player who began showing symptoms of illness after Christmas break in January 2011 while beginning preseason for rugby. Initial symptoms included severe stomach pain, nausea and vomiting. She was an active participant in sports since childhood and was accustomed to the conditioning requirement of sports activities and denied having any previous history of this illness and/or stomach condition. The athlete does present a unique set of risk factors including hypothyroidism, and polycystic ovarian syndrome as well as being diagnosed with pre-diabetic numbers.The athlete was referred to the physician and a series of general medical tests were ordered. While the tests were being completed the athlete was allowed to continue playing and would leave practice as necessary when feeling sick. **Differential Diagnosis:** Parasite, flu, stomach virus, and gastroparesis. **Treatment:** Athlete underwent a series of tests to determine the cause of her stomach pain and nausea. Complete series of blood work was done and examined. Tests revealed abnormally high liver levels while her parasite tests came back negative. Athlete returned to playing as tolerated but was still experiencing an upset stomach regularly and opted to head home for a second opinion from her personal gastroenterologist. Her physician went through his own sets of parasite testing and blood work and results again were negative. A colonoscopy and endoscopy were then ordered athlete was required to stop eating two days prior to her test. The tests could not be completed as a result of a large amount of food found undigested in her stomach and large intestine. Results from these tests led the Gastroenterologist to believe she was suffering from gastroparesis which results in the delayed emptying of stomach contents leading to the decline in her digestion process thus causing fermentation of food in the stomach. Using the results of this test she was officially diagnosed with gastroparesis. Athlete was given a prescription for diphenoxylate/ atropine 2.5mg and sought consultation with a nutritionist. **Uniqueness:** Athlete's case of gastroparesis was idiopathic. Causes for idiopathic gastroparesis are still largely unknown. Gastroparesis tends to be an illness that affects people who have been suffering from diabetesfor a minimum 10 years (Camilleri et al). In this case the athlete is not diabetic but is classified as having pre-diabetic numbers. The majority of patients suffering from gastroparesis are older females (82%) with the mean onset about 34yrs of age (Soykan et al). **Conclusions:** Athletes may suffer from underlying conditions that are never truly recognized before their onset. For this athlete, a slight illness presented an environment for a significant illness to be revealed. She has begun working alongside a sports nutritionist at school and now has a specific diet to eat which includes a list of safe foods that are easier for her body to properly digest. Even with medication the athlete is unable to digest many foods and still suffers from an upset stomach from time to time. The long term goal is to maintain proper nutrition and to remember that everything is based upon personal tolerance. There is trial and error period with the goal of finding what her body can and cannot tolerate. More observation and testing will be needed to help this athlete return to a normal life. A support system should be put into place and those involved with the situation should learn how they can provide the athlete the best care and environment for her illness. As a result of her nutritional adjustments she does not plan on returning to play but hopes to adjust daily to her new found way of life.

Grade 1 Chondrosarcoma in a Collegiate Volleyball Player

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Background: A 19-year-old, 5'10", 150lb Hispanic female collegiate volleyball player was suffering a gradual onset of right shoulder pain. The team's athletic trainer performed a complete musculoskeletal evaluation of the patient, and made a clinical diagnosis of a grade 1 acromio-clavicular joint sprain of the right shoulder. After two weeks of treatment, rehabilitation, and reduced activity, the patient's pain had not decreased. She was then referred to the team orthopedic surgeon. Bilateral x-rays revealed a bony abnormality on the left humerus. The patient had not displayed signs or symptoms of discomfort or pain when the left shoulder and arm were evaluated. The patient was withheld from all activity until MRI imaging was completed and reviewed by an orthopedic oncologist. **Differential Diagnosis:** Bony abnormality, chondrosarcoma, osteo-porosis, osteosarcoma, fibrosarcoma. **Treatment:** The patient was seen by an orthopedic oncologist who determined the diagnosis of osteosarcoma. The patient was then sent to a cancer center where a needle biopsy, contrast MRI, chest x-ray, bone scan, and blood tests were performed. Test results indicated the patient's final diagnosis of grade 1 chondrosarcoma in the left proximal humerus. The patient was disqualified from volleyball due to the risk of fracture and spread of the cancer cells. She will receive surgery to remove the tumor following her fall semester of school. **Uniqueness:** The patient's initial injury was an acromioclavicuar

joint sprain of the right shoulder, and she showed no signs or symptoms of pathology to her left shoulder. Also, chondrosarcoma is usually diagnosed in adults over the age of 40, and rarely occurs in children or adolescents. **Conclusion:** This case report emphasizes the importance of bilateral comparisons of injuries and persistence to look beyond the primary injury for other ailments. Athletic trainers and other allied healthcare professionals need to perform consistent and in depth evaluations of the injuries they come in contact with because some patients may have a condition that displays no signs or symptoms until aggravated or seen through further studies.

Thoracolumbar Pain in a Female Collegiate Gymnast

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Background: A 22 y/o female gymnast complained of immediate severe sharp thoracolumbar pain without the presence of radiating pain, unusual sounds, or sensations secondary to landing on her thoracolumbar spine forcing spinal hyperflexion after failing to perform a full twisting front tuck somersault from the balance beam. The patient was unable to walk and reported that pain was aggravated by movement and alleviated by rest. Visual inspection revealed patient apprehension for movement without the presence of swelling or deformity. Physical examination elicited palpable tenderness over the thoracolumbar spinous processes with associated spinal extensor muscle spasm. Range of motion was severely restricted by pain and spasms and subsequently not performed. Neurological screening was able to rule out associated spinal cord injury. The patient's medical history was not significant for traumatic injuries to the spine or surrounding area. **Differential Diagnosis:** vertebral body compression fracture, spinous process fracture, transverse process fracture, vertebral arch fracture, spinal ligament sprain, facet casulary sprain, erector spinae (iliocostalis, longissimus, and spinalis) strain, and internal organ derangement. **Treatment:** After initial evaluation, emergency medical services was summoned, the patient was immobilized with a full backboard, and transported to a local emergency medical facility for further evaluation. Thoracolumbar radiographs were obtained and revealed a decreased anterior border vertebral height without subsequent interspinal space increases. She was diagnosed with a T_{12} and L_1 compression fracture and was placed in a thoracolumbar sacral orthosis (TLSO). Early rehabilitation consisted of spinal immobilization to relieve pain, spasms, and soft tissue restrictions for 12 weeks. Status post 12 weeks, the patient was removed from the TLSO and a more aggressive rehabilitation program was implemented which included restoring hip muscle balance, flexibility, strength, and muscular endurance. Status post 18 weeks, the patient was functionally stable and core stabilization and strengthening with application for gymnastic activities was incorporated into the rehabilitation program. Status post 26 weeks, the patient was discharged from rehabilitation; however, she was unable to return to competitive gymnastics due to the exceptional physical and mental demands of the sport. **Uniqueness:** Thoracolumbar spinal fractures are very rare in athletics. Common causes are high velocity high-energy impacts such as car accidents. Other susceptible populations are older individuals with osteoporosis or spinal tumors, and in younger individuals with a history of steroid use. Specifically, in this case, the young and otherwise healthy patient suffered a career ending injury. Also, the mechanism of injury was very unique. The dismount caused her torso to remain in motion, forcing the spine in hyperflexion, resulting in the fracture. Furthermore, this pathology did not affect ligamentous stability or cause secondary spinal cord injury. Lastly, based on the literature, management for this pathology required an additional 6 weeks of non-operative bracing due to a lack of complete osseous healing. **Conclusion:** In the sport of gymnastics, when situations go awry in the air, gymnasts are instructed to perform a tuck and roll maneuver to ensure a safe landing to prevent injury. Unfortunately, the gymnast could not complete this maneuver in sufficient time, causing injury. The mechanism of injury in this case is very important to recognize in order to identify the clinical presentation, give appropriate immediate care, and provide proper post-injury management. Thoracolumbar fracture management can include non-operative bracing for neurologically intact pathologies. Disability from this pathology can last up to 6 months. With no neurologic damage, patients may return to full athletic participation provided they are free of pain during activity and core stability and strength is adequate to meet the specific demands of the participant's activity.

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