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## Supplement to

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# JOURNAL OF ATHLETIC TRAINING

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## Take this *Supplement* to Philadelphia 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 2010 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 Philadelphia 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 NATAREF Free Communications Program. We are happy to report a record number of submissions this year with the total exceeding 400 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 the all of the NATA Foundation staff and especially Patsy Brown, Velma Meza, Ty Jones and Teresa Foster-Welch, 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: Karrie Hamstra-Wright, PhD, ATC; Lisa Jutte, PhD, ATC; Tom Kaminski, EdD, ATC; Darin Padua, PhD, ATC; Kim Peer, EdD, LAT, ATC; William Pitney, EdD, ATC; Brian Ragan, PhD, ATC; ATC, PT; Stephen Straub, PhD, ATC; Erik Swartz, 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 Philadelphia. 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,

Tom Dompier, PhD, ATC
Vice Chair for Free Communications
NATA Research & Education Foundation Research Committee

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## Free Communications: Room 202AB

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# The Medal for Distinguished Athletic Training Research Presented in Honor of Joe Torg, MD Sponsored by Riddell, Inc


## Thomas G. Weidner, PhD, ATC, FNATA
## Ball State University


As a youngster, Thomas Weidner, PhD, ATC, FNATA, enjoyed playground sports. As he grew older, however, he found his niche in athletic training, keeping him connected to the sports he loved as a child despite vision loss. This lifelong dedication has now earned him the Medal for Distinguished Athletic Training Research.

Dr. Weidner's passion for research began during his doctoral studies and continued as he progressed into the faculty ranks. He enjoys research because it challenges him to discover new knowledge, present those findings, and publish them. The more he has researched, the more passionate he has become, and today, he describes research as the best part of his job. Dr. Weidner's primary research concentration is in athletic training education. As a young faculty member and program director, he sought guidance from the literature about how to implement an effective clinical athletic training education program. He found little such research and so, for very practical reasons, set out to discover that knowledge himself and apply it to his own education program, making him the first researcher distinguished primarily for athletic training educational research.

Dr. Weidner's secondary research concentration is upper respiratory illness (URI). As an assistant athletic trainer, he was surprised by the number of athletes wanting advice about URIs. Few recommendations were available, so once again, the solution was to pursue research as a faculty member in order to offer guidelines and recommendations.

Currently, Dr. Weidner is studying peer-assisted learning (PAL), with the goal of understanding the various types of PAL that occur during clinical education for athletic training students. This entails analyzing, developing, and recommending strategies for optimizing PAL in order to free staff athletic trainers to provide health care to athletes and patients. Peer-assisted learning allows students opportunities to collaborate, providing excellent preparation for their future roles as health care professionals. Dr. Weidner is also actively researching how formal and informal continuing education can benefit athletic trainers. Finally, Dr. Weidner is assisting in research toward the implementation of standardized patients in athletic training clinical education.

Being a leader in athletic training education and providing guidelines for physical activity for persons with URIs are important to Dr. Weidner. One of his most rewarding experiences is receiving feedback on research that people have found meaningful, valuable, and helpful. He would like to be remembered as a servant to his family, friends, students, and colleagues.


Dr. Weidner would like to thank his father, Larry Weidner, for modeling hard work and conscientiousness; his wife, Lauren Bishop-Weidner (who also teaches at Ball State University), for helping him to develop writing and critical-thinking skills; his research colleague, Elliot Dick, PhD, who taught him much about due diligence and excellence; and his doctoral assistants and faculty colleagues over the years, who have kept him challenged and energized.


In encouraging his athletic training colleagues and friends to pursue their professional passions, Dr. Weidner considers the Medal for Distinguished Athletic Training Research a high honor and throws down the gauntlet by reminding them that he achieved it "with [his] eyes closed"!

# Joe Torg, MD

Joe Torg, MD, has long been a leader in sports medicine. Widely recognized for his work with spinal cord injuries, Dr. Torg is also responsible for perfecting medical techniques and spurring participation guidelines in sports.

A graduate of Haverford College and the Temple University School of Medicine, Dr. Torg is the founding director of the Temple University Center for Sports Medicine, the first affiliated with a university, which provided care for the athletes of Philadelphia. His research on the effect of the shoe–playing surface interface and its relationship to football knee injuries was directly responsible for both the National Federation of State High School Associations and the National Collegiate Athletic Association mandating that cleats be no longer than one-half inch. His published description of the Lachman Test for anterior cruciate ligament instability, which he named for his professor, John Lachman, MD, is widely regarded as a classic work. Dr. Torg was also instrumental in opening Little League baseball to girls.

Dr. Torg's most well-known contribution has been his research identifying catastrophic cervical spine and cord injuries that result from the previously unrecognized axial loading mechanism of the spine from spearing and head-down contact. After analyzing data from the National Football Head and Neck Injury Registry, Dr. Torg recommended rule changes that resulted in a marked decrease in cervical cord injuries resulting in quadriplegia at both the high school and college levels. He also described cervical cord neurapraxia resulting in transient quadriplegia as a distinct, benign clinical entity. Dr. Torg has published criteria for return to play following cervical spine injury.

In 1978, Dr. Torg was appointed Professor of Orthopedic Surgery and Director of the University of Pennsylvania Sports Medicine Program, where he initiated one of the first Sports Medicine Fellowships. He has since trained 36 fellows.

Dr. Torg has co-authored three textbooks and well over 100 articles published in prestigious peer-reviewed journals. He served on President Reagan's Council on Physical Fitness and Sports.

Dr. Torg received the Ninth Annual Eastern Orthopedic Association award for spinal research, the Nicholas Andre Award, the North American Spine Association annual award, the NATA President's Challenge award and the 2004 Elizabeth Winston Lanier Kappa Delta award. He is also an AOSSM Hall of Fame member.

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

## Erik Wikstrom, PhD, ATC
## University of North Carolina at Charlotte

For Erik A. Wikstrom, PhD, ATC, interest in athletic training and sports medicine started with his participation in high school athletics. Although he felt that he was not skilled enough to continue sports at an elite level, his interest led him to Roanoke College and a B.S. degree in athletic training. But it was during his time as a master's and doctoral student at the University of Florida that he discovered his passion for research, and he cites his fascination with puzzles as the reason he enjoys research.

The majority of Dr. Wikstrom's research focuses on the interactions among musculoskeletal biomechanics and sensorimotor control of the lower extremity after ankle sprains and the development of ankle instability, with particular emphasis on the coordination of dynamic balance. As a result, his work crosses multiple disciplines, including biomechanics, motor control, and rehabilitation sciences, but the common goal is to identify the impairments that result from ankle sprains and the impairments that lead to ankle instability. He noted that, "despite the fact that ankle sprains are the most common injury associated with physical activity and that ankle sprains have serious long-term consequences, such as joint instability and osteoarthritis, ankle sprains are often incorrectly considered an insignificant injury."

For his doctoral dissertation, Dr. Wikstrom sought to identify differences between those who have ankle instability and those who have sprained their ankles but not developed ankle instability. He believes these projects were the first step in the development of a classification scheme that could identify individuals more likely to develop ankle instability. His current work continues to identify differences between those with instability and without instability after an ankle sprain. He is also researching therapeutic interventions for those with sprained ankles and ankle instability. His ultimate goal is to be able to identify people more likely to develop ankle instability, so that they can be treated with effective evidence-based rehabilitation protocols to minimize lifelong dysfunction.

Dr. Wikstrom is currently an assistant professor at the University of North Carolina at Charlotte, where he teaches in the Department of Kinesiology. His most rewarding experiences as an educator include witnessing the proverbial "light bulb" go on and watching students grow from nervous and unsure freshman to confident graduates with a mature perspective on life and education.

When asked about his legacy, he stated, "I hope to be remembered as someone who worked hard and set a good example for students, friends, and colleagues." He also wants to be remembered as someone who has given back to the field of athletic training.

As contributors to his success, Dr. Wikstrom thanks his undergraduate athletic training mentors, Jim Buriak, MS, ATC, and Cheryl Staver, MS, ATC, for challenging him to reach his full potential; his friends, Geoffrey C. Dover, PhD, ATC, CATA(C); Keith E. Naugle, PhD, ATC; and Tricia J. Hubbard, PhD, ATC, for their support; his doctoral dissertation committee chairs, Paul A. Borsa, PhD, ATC, FACSM, and Mark D. Tillman, PhD, for their leadership and guidance; his parents, Gerry and Ray Wikstrom, for instilling in him his work ethic; and his wife, April, for her unwavering love and support.

# David H. Perrin, PhD, ATC

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.

# EBF: Shoulder

Wednesday, June 23, 2010, 8:15AM-9:15AM, Room 201C; Discussants: Jason Scibek, PhD, ATC, and Sakiko Oyama, MS, ATC; Moderator: W. Steven Tucker, MS, ATC

# Free Communications, Oral Presentations: Diagnostic Issues Related To Shoulder Pathology in Overhead Athletes

Wednesday, June 23, 2010, 9:30AM-10:45AM, Room 201C; Moderator: Phil Donley, MS, ATC, PT

**Role Of Humeral Torsion In Collegiate Pitchers With Throwing-Related Upper Extremity Injury History**

Myers JB, Oyama S: Department of Exercise and Sport Science, University of North Carolina at Chapel Hill, Chapel Hill, NC

**Context:** Increased dominant limb humeral torsion has been demonstrated in collegiate baseball pitchers. However, whether the increased humeral torsion plays a detrimental or protective role in development of the throwing-related shoulder and elbow injury is under debate. Despite the high incidence of throwing-related shoulder and/or elbow injury in the baseball pitchers, the role that humeral torsion plays in injury has not been examined. **Objective:** To determine if differences in humeral torsion are present in collegiate pitchers with and without a history of throwing-related shoulder or elbow injury. **Design:** Cross-sectional study. **Setting:** A university biomechanics laboratory. **Patients or Other Participants:** Thirty-six Division I collegiate pitchers (age=19.4±1.1yrs; height=183.3±7.4cm; mass=88.6±12.3kg; years played 14.4±1.6yrs; years pitched =7.8±4.1yrs) participated. Of the 36 participants, 12 had a history of shoulder injury, while 13 had a history of elbow injury that limited participation in the past three years. **Interventions:** Bilateral humeral torsion was measured using ultrasonography and digital inclinometry as the angle of humeral rotation (forearm angle from horizontal) when the proximal humerus was placed in a standardized position where the humeral tubercles were aligned with the horizontal plane (visualized with ultrasound) (ICC=.96-.98, SEM=2.0-2.3°). Participants were also surveyed about upper extremity injury. Group comparisons were made between pitchers with and without shoulder injury history and pitchers with and without elbow injury history, using independent t-tests. **Main Outcome Measures:** Mean dominant limb humeral torsion (HTD), non-dominant limb humeral torsion (HTN), and humeral torsion limb difference (HTΔ) were calculated as the average of three trials. **Results:** The pitchers with elbow injury history (EI) exhibited significantly greater HT compared to the pitchers with no history of elbow injury (NEI) (EI = 21.7±7.7°, NEI = 13.8±10.4°; p=.03). No group differences were present in HTD (EI = 83.9±9.3°, NEI = 80.7±7.3°; p=.26) and HTN (EI = 63.6±12.9°, NEI = 66.8±8.8°; p=.38). No difference in any of the humeral torsion variables were present in the pitchers with shoulder injury (SI) compared to the pitchers with no history of shoulder injury (NSI) (HTD: SI=81.7±9.7°, NSI=81.9±7.4°, p=.92; HTN: SI=63.7±12.2°, NSI=66.7±9.5°, p=.43; HTΔ: SI=18.0±13.3°, NSI=15.8±8.3°, p=.55). **Conclusions:** Collegiate pitchers with a history of elbow injury exhibited a greater limb difference in humeral torsion, which indicates greater humeral torsion in dominant limb after controlling for inter-subject difference in the baseline (non-dominant). Therefore, the greater humeral torsion difference present in the participants with elbow injury history suggests that humeral torsion may play a detrimental role in the development of elbow injury in pitchers. Humeral torsion appears to play no detrimental or beneficial role in shoulder injury given that torsion characteristics were not different between the participants with and without a history of shoulder injury.

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**Effect Of A 6-Week Strengthening Program On Shoulder And Scapular Stabilizer Strength And Functioning In Division I Collegiate Swimmers**

Hibberd EE, Myers JB, Oyama S, Prentice WE, Spang JT: University of North Carolina at Chapel Hill, Chapel Hill, NC

**Context:** Shoulder injuries are common in swimmers due to the demands of the sport and are often caused by muscular imbalances and weakness. These injuries are often treated with rest, which can quickly result in detraining. Therefore, improvement in muscle strength may prevent shoulder injury, which is paramount for competitive swimmers to train successfully. **Objective:** To assess the effectiveness of a 6-week intervention program on shoulder and scapular stabilizer muscle strength and subjective measures of shoulder function and satisfaction in collegiate swimmers. **Design:** Randomized control trial. **Setting:** University research laboratory and natatorium. **Participants:** Thirty-eight division-one collegiate swimmers with no current shoulder injury were randomly assigned to experimental (n=20, age= 19.2± 1.2years, mass=73.1±9.9kg, height=177.5 ±9.8cm) and control groups (n=18, age=19.4 ±1.2years, mass=72.8 ±12.4kg, height= 178.1±8.7cm). **Interventions**: Shoulder musculature and scapular stabilizer strength and subjective reporting of shoulder function and satisfaction were assessed before and after the 6-week period during which the exercise group performed the resistant tubing exercises previously demonstrated to activate rotator cuff and scapular stabilizer muscles and stretching exercises, while the control group did not perform the exercises. The experimental group performed the exercises three times a week. The exercises performed included Ys, Ts, Ws, shoulder flexion, low rows, throwing acceleration and deceleration, dynamic hugs, and shoulder internal rotation and external rotation at 90° abduction as well as the sleeper and corner stretches. Shoulder and scapular muscle strength were measured by blinded examiners as the maximum force recorded during a break test using a handheld dynamometer. The Single Assessment Numeric Evaluation (SANE) and the Sports Module of the Disabilities of the Arm, Shoulder, and Hand (DASH) were used as subjective measures of shoulder function and satisfaction. **Main Outcome Measures:** Each strength measures were taken three times at pre and post intervention sessions to calculate the three-trial mean. Difference scores (post-pre test values) were calculated for all strength variables and SANE and DASH scores. Separate independent samples t-tests were performed to assess difference in change scores for strength and subjective rating between the treatment and the control group. **Results:** A significantly greater improvement in dominant shoulder flexion (mean diff=32.5±12.5N, $t_{(36)}$=2.6, p=.012) and abduction (mean diff=34.4±12.5N, $t_{(36)}$=2.75,p=.009) strength was found in subjects in the treatment group compared to the control group. Trends toward improve-

ment were also found in the treatment group on shoulder internal rotation (mean diff= 27.1±17.3N,$t_{(36)}$=1.57,p=.125) and DASH composite score (mean diff= 5.45± 3.87,$t_{(36)}$ =1.41,p=.167). **Conclusions:** Muscle strength and subjective measures of functioning in Division I collegiate swimmers can be improved by implementing a resistance tubing program. Improving the strength variables may lead to a decreased incidence of shoulder injury and pain in swimmers, as well as improving the swimmers' subjective reporting of shoulder function.

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**Scapular Dyskinesis In Sport Participants With Subacromial Impingement: Relationship To Impairments, Pain, Function, And Rehabilitation Outcome**

Seitz AL, Michener LA, McClure PW, Tate AR, Thigpen CA: Department of Physical Therapy, Virginia Commonwealth University- Medical College of Virginia, Richmond, VA; Arcadia University, Glenside, PA; Proaxis Therapy, Greenville, SC

**Context:** Scapular kinematic alterations have been found in patients and athletes with impingement; however, not all individuals with impingement present with scapular dyskinesis. This suggests a distinct subgroup. Identifying homogenous subgroups is necessary to improve treatment effectiveness. **Objective:** To determine if scapular dyskinesis differentiates severity of impairments, pain, and function in sport participants with subacromial impingement syndrome (SIS). We hypothesized subjects with dyskinesis will have a different pattern of impairments, level of disability, or outcome than those without dyskinesis. **Design:** Prospective cohort-control. **Setting:** Clinics. **Patients:** Sport participants (n=42; 21M, 21F; 45.7±15.5 years) in a multicenter clinical trial who received treatment for SIS. **Interventions:** Standardized treatment of exercise and manual therapy for 8-10 treatments over 6-8 weeks. **Main Outcome Measures:** Scapular dyskinesis was evaluated at initial exam (IE) and discharge (DC) using a method with demonstrated reliability and validity; obvious dyskinesis defined by observation of striking or clearly apparent winging or dysrhythmia during 3 of 5 repetitions of arm raising/lowering. Impairments of scapular muscle strength, shoulder internal/external rotation and horizontal adduction passive range of motion were assessed. Outcomes collected at IE, 2 weeks, 4 weeks, and DC were pain with rest, normal activities and strenuous activities each rated on a numeric 0-10 scale, function with the Disabilities of Arm Shoulder Hand (DASH), and global change with a 13-point (GROC) scale. Outcome at DC was dichotomized as successful or not successful; successful outcome defined as at least 50% change in DASH score from IE to DC and 'moderately better' on the GROC. Impairments, pain, function and outcome were compared with ChiSquare (categorical), t-tests (continuous), and repeated measures mixed-model ANOVAs ($\alpha$=0.05). **Results:** At IE, 11/42 (26.2%) participants had obvious dyskinesis and 31/42 (73.8%) did not. There were significant improvements in outcomes at DC ($P$<0.001) for all participants regardless of presence/absence of obvious dyskinesis. There was no difference in dichotomized outcome between those with and without obvious dyskinesis (ChiSq=0.1, $P$=0.76); successful outcome was achieved by 8/11 (72.3%) with obvious dyskinesis and 21/31 (67.7%) without. Subjects with obvious dyskinesis demonstrated no significant differences in impairments, pain, or DASH at IE or pain, DASH, or GROC ($P$>0.05) at DC compared to those without obvious dyskinesis. At 4 weeks the participants with obvious dyskinesis had less improvement in pain (t=4.6, $P$=0.04). At DC, there were n=3 with obvious dyskinesis and n=36 without. Despite trends, this was not statistically different from IE (ChiSq=2.1, $P$=0.12). **Conclusions:** Presence of scapular dyskinesis did not differentiate impairment, pain, or function in sport participants with SIS. Trends suggest the presence of obvious scapular dyskinesis may improve with treatment; however, scapular dyskinesis has no relationship to self-report outcome and should be used with caution to determine progress in patients with SIS.

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**The Relationships Between Injury Status, Self-Reported Pain, Injury History And The Functional Arm Scale For Throwers© (FAST©) In Baseball Athletes**

Huxel KC, Sauers EL, Bay RC, Snyder AR: Post-Professional Athletic Training Program, A. T. Still University, Mesa, AZ

**Context:** The incidence of upper extremity injury in baseball athletes is high. Patient self-report scales provide insight on patients' health-related quality of life (HRQOL). **Objective:** To examine relationships between self-reported injury status and pain, upper extremity injury history, and HRQOL in baseball athletes. **Design:** Cohort. **Setting:** Athletic training facilities. **Patients or Other Participants:** Convenient sample of 149 baseball athletes [Healthy (n=88): pitcher=39, infielder=35, outfielder=12, other=1; Injured (n=61): pitcher=31 infielder=16, outfielder=14; Age = 20.0±2.0 years]. **Interventions:** Survey instruments were mailed to athletic trainers who distributed forms to baseball athletes. All athletes completed a demographic questionnaire, including questions about health and injury status to classify them as healthy or injured. Injured athletes also completed questions about their injury, including affected side, acute/chronic, pain, history of surgery, and participation status. All subjects completed the FAST©, which is a region-specific, self-report scale for the arm specific to throwing athletes. Pitchers also completed the FAST© pitching module (F-PM). High scores indicate more disability and low HRQOL. The FAST© was developed using a sound empirical process and its development is ongoing. **Main Outcome Measures:** Self-reported data including injury status, self-reported pain, injury and surgery history, and participation status were tabulated. Scores were calculated for FAST© total (F-T), pain (F-P), impairment (F-I), functional limitation (F-FL), disability (F-D), and societal limitation (F-SL) subscales, and F-PM. Point bi-serial correlations were used to examine relationships between self-reported data and FAST© scores. **Results:** There was a moderate relationship between injury status (healthy vs. injured; 61 injured/149 total, 41%) and F-T(r=.68, p<.001), F-P(r=.59, P<.001), F-I(r=.59, P<.001), F-FL(r=.64, P<.001), F-D(r=.73, P<.001), F-SL(r=.40, P<.001) and F-PM(31injured pitchers/70 total pitchers, 44%; r=.63, P<.001). In the injured athletes, there was a weak relationship between higher FAST© scores and previous surgery on the currently injured arm (21/57, 37%) for F-T(r=.30, P=.046) and F-D(r=.44, P=.002). There were weak to strong relationships between participation status (unlimited = 9/57, 16%; limited = 24/57, 42%; no participation = 24/57, 42%) and F-T(r=.58, P<.001), F-P(r=.48, P=.001), F-I(r=.38, P=.009), F-FL(r=.46, P=.002), and F-D(r=.82, P<.001). There was little relationship between number of days out of participation and F-D(r=.36, P=.030). There was no relationship between injury type (acute, chronic), use of pain medications, and number of days in pain and F-T or any of its subscales (r=.02-.27, P=.257-.910). There was a moderate relationship between pitcher participation status (unlimited=4/27, 15%; limited=8/27, 30%; none=15/27, 56%) and F-PM(r=.55, P<.009). **Conclusions:** A history of surgery, decreased participation, and increased number of days out of participation in injured baseball athletes were related to higher FAST© scores, indicating diminished HRQOL in these athletes. Using these variables, the FAST© appears to discriminate between the healthy and injured baseball athletes tested, particularly for the F-T and F-FL and F-D subscales.

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**Diagnostic Accuracy Of History And Physical Examination For Categories Of SLAP (Superior Labral Anterior To Posterior) Lesions Of The Shoulder**

Michener LA, Doukas WC, Murphy KP, Walsworth MK: Department of Physical Therapy and Radiology, Virginia Commonwealth University, Richmond, VA; Department of Orthopaedics and Rehab, Walter Reed Army Medical Center, Washington, DC; Heekin Orthopedics, Jacksonville, FL

**Context:** Superior Labrum Anterior to Posterior (SLAP) lesions are categorized as Type I-IV. Type I involve degenerative fraying that can be a normal variant and likely asymptomatic, while Type II-IV are tears of the labrum. Because interventions are likely different between the categories of Type I and II-IV, diagnostic utility should be examined for these SLAP categories. **Objective:** Examine the diagnostic accuracy of the history and physical examination for two categories of SLAP lesions, Type I and Type II-IV. We hypothesized that the history and tests will have different diagnostic ability for confirming and excluding the two SLAP lesion categories. **Design:** Prospective diagnostic study. **Setting:** Outpatient clinics. **Patients:** Consecutive patients (n=55) with shoulder pain presenting to orthopaedic surgeon offices (mean age: 40.6 ±15.1 years, 47 males) participated. **Interventions:** A standardized history and physical examination was performed by one of two orthopedic surgeons. Specifically a history of trauma, sudden onset of symptoms (symptoms started at a defined point in time), and popping, clicking or catching with use of their shoulder was recorded. Clinical tests were performed of active compression, crank and anterior slide, recording the test result of positive or negative as defined by the test original description. Patients underwent surgery; the reference standard was the intra-operative diagnosis. A labral lesion was confirmed by visualization of tearing or detachment of the labrum during surgery. The operating surgeon was blinded to the results of the history and examination. **Main Outcome Measures:** For each SLAP category, the area under the curve (AUC) using receiver operating characteristic curve was calculated to determine the ability to discriminate between the presence and absence of SLAP lesion. Next, diagnostic accuracy values were calculated of sensitivity, specificity, positive likelihood ratio (+LR) and negative likelihood ratio (–LR). Finally, binary logistic regression analysis was used to determine the optimal test combination. **Results:** No history or physical test singularly or in combination had diagnostic utility for Type 1 SLAP(n=13). To both confirm and exclude Type II-IV SLAP(n=10), the anterior slide test singularly was the only test that had diagnostic utility (AUC=0.70;+LR=2.25,—LR=0.44). The combination of pop, click, or catch and anterior slide demonstrated utility to confirm (+LR=6.0) Type II-IV SLAP. **Conclusions:** This first study examining the diagnostic accuracy of history and tests singularly and in combination for two SLAP lesion categories indicates diagnostic utility of history and tests for Type II-IV SLAP tears only. No single test or test combination had diagnostic utility for Type I SLAP. For Type II-IV SLAP, the anterior slide test demonstrated diagnostic utility to both confirm and exclude Type II-IV SLAP. The anterior slide in combination with a history of pop, click, or catch was useful to confirm but not to exclude Type II-IV SLAP.

## Free Communications, Oral Presentations: Examining Sensory-Motor Characteristics in the Acute Ankle

Wednesday, June 23, 2010, 11:00AM-12:00PM, Room 201C; Moderator: Eric Nussbaum, MEd, LAT, ATC

**Normal Ankle Sensation Can Be Established Before Or After Cryotherapy By Measuring The Contralateral Ankle**

Jutte L: Ball State University, Muncie, IN

**Context:** Cryotherapy is thought to reduce orthopedic pain by reducing sensation. Sensation of pressure is one method for quantifying sensation and is defined as the smallest amount of pressure needed to elicit a response; therefore, as sensation decreases the pressure needed to elicit a response increases. We know that cryotherapy decreases sensation in healthy subjects. If we could establish the relationship between the decreases in superficial sensation and orthopedic pain of deeper origin, then we could use sensation measurements to establish more effective cryotherapy guidelines for treating orthopedic pain. We assert that orthopedic injury could influence sensation. Consequently, a method for determining normal sensation, i.e. unaffected by injury or treatment, for injured individuals first needs to be established. We questioned, then, whether one ankle could serve as a baseline sensation measurement for the contralateral ankle, and whether that ankle's sensation would be influenced by cryotherapy to the contralateral ankle. **Objective:** The objectives for this study are: 1) To determine if sensation over the anterior talofibular (ATF) ligament is similar bilaterally; 2) To determine if sensation over the ATF is effected by cryotherapy application to the contralateral ankle. **Design:** 2 x 2 x 2 crossover study. Independent variables were limb (right & left), treated limb (treated v. non-treated), & time (pre- & post-cryotherapy). **Setting:** Athletic Training Research Laboratory. **Other Participants:** Nineteen individuals (10 male, 9 female; 21.8 ± 3.0 yrs; 174.1 ± 11.7 cm; 75.2 ± 14.1 kg) who denied lower extremity injury and any loss of lower limb sensation volunteered. **Interventions:** Subjects reported on 2 occasions separated by a minimum of 24 hours. At each session they received a 15-minute cold water immersion treatment (~ 1°C) to an ankle. **Main Outcome Measures:** Ankle sensation of pressure (g) over the ATF was measured bilaterally with Semmes-Weinstein nylon monofilaments before and after unilateral ankle cold water immersion. **Results:** Sensation did not differ between ankles prior to immersion (R: 2.0 ± 1.4g; L: 2.1 ± 1.6g; $F_{1,17} = .76$; $P = .91$). After immersion, sensation decreased in treated ankles only (Non-treated Pre: 2.0 ± 1.3 g; Treated Pre: 2.1 ± 1.6 g; Non-treated Post: 3.2 ± 3.2 g; Treated Post: 15.5 ± 17.5 g) ($F_{1,17} = 17.54$; $P < .05$). **Conclusions:** Sensation is similar between healthy ankles within an individual. Treating one ankle with cold water immersion does not affect the sensation of the contralateral ankle. Future studies should determine whether injury changes sensation of pressure, and the relationship between decreased superficial sensation from cryotherapy and ankle injury pain. It appears that researchers can use the untreated contralateral ankle to establish baseline superficial sensation.

**Effect Of Acute Lateral Ankle Sprain On Motor Neuron Pool Excitability Of The Soleus, Anterior Tibialis And Peroneus Longus**

Klykken KW, Pietrosimone BG, Kim KM, Ingersoll CD, Hertel J: University of Virginia, Charlottesville VA; University of Toledo, Toledo, OH; Central Michigan University, Mount Pleasant, MI

**Context:** Decreased motor neuron pool excitability (MNPE) has been reported in patients with chronic ankle instability. Although decreased MNPE has been hypothesized to be a factor contributing to the pathogenesis of chronic ankle instability, it remains unknown if MNPE deficits are present in individuals with acute lateral ankle sprains. **Objective:** To determine the effect of acute lateral ankle sprains on MNPE of the soleus, tibialis anterior and peroneus longus between involved and uninvolved limbs and compared to healthy matched controls. **Design:** Case control. **Setting:** Laboratory. **Patients or Other Participants:** Ten individuals with acute ankle sprains (6 females, 4 males; age 19.2±3.8 yrs; 169.4±8.5 cm; 66.3±11.6 kg) and ten healthy matched controls participated (6 females, 4 males; age 20.6±4.0 yrs; 169.9±10.6 cm; 66.3±10.2 kg). **Intervention:** The independent variables were group (ankle sprain, healthy) and limb (involved, uninvolved). Limbs of the controls were side matched to the involved limb of the injured counterpart. Six separate dependent t-tests were used to assess differences in MNPE in each of the 3 muscles between legs of the ankle sprain and healthy groups. Between leg difference scores were calculated for each muscle (injured –uninjured) in both groups, and 3 separate independent t-tests were used to assess differences in between leg difference score between groups. A priori levels of significance were set at $P \leq 0.05$. **Main Outcome Measures:** MNPE of the soleus, peroneals and tibialis anterior was evaluated by normalizing Hoffmann reflexes to maximal muscle (M) responses (H:M ratio). **Results:** The soleus MNPE in the ankle sprain group were significantly higher in the injured limb compared with the uninjured limb (.62 ± .22 v .47 ±. 24, $t_6$=3.62, P=.01) in the ankle sprain group. Tibialis anterior MNPE tended to be decreased in the involved ankles compared to the uninvolved side in the sprained group but did not reach statistical significance (.05 ± .07 v .22 ± .22, $t_9$=-2.01, P=.07). No differences were detected between injured and uninjured ankles for the peroneus longus in the ankle sprain group (.22 ± .12 v .25 ± .22, $t_9$=-.739, P=.48). There were no significant side-to-side differences in $H_{max}$:$M_{max}$ ratios for the soleus (.59 ± .25 v .54 ± .26, $t_7$=.693, P=.51), peroneals (.24±.11 v .24±.17, $t_8$=-.235, P=.82), and tibialis anterior (.15±.8 v .17±.17, $t_9$=-.729, P=.484) in the healthy group. Tibialis anterior between leg difference scores were lower in the ankle sprain group (-16 ± 24.6 v. 2.6 ± 11.5, $t_{18}$= -2.19, P=.42), while no differences were found between groups for the soleus or peroneals. **Conclusions:** Although significant differences were not found in peroneus longus or anterior tibialis MNPE, evidence of an arthrogenic muscle response seems to be present in the soleus muscles of patients with acute ankle sprains. Funded by the NATA Foundation Master's Research Grant Program.

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**Reliability Of One-Way And Total Laxity Measurements Of The Ankle Complex Derived From An Instrumented Arthrometer**

Kovaleski JE, Schwarz NA, Heitman RJ, Gurchiek LR, Hollis JM, Pearsall AW: University of South Alabama, Mobile, AL

**Context:** This study continues a long-term effort to develop a reliable, quantitative diagnostic tool for assessing ankle complex laxity. Earlier efforts led to the development and validation of a six-degrees-of-freedom instrumented linkage (Hollis Ankle Arthrometer) capable of measuring the anteroposterior (AP) and inversion-eversion (I-E) laxity characteristics of the ankle complex. Good to excellent correlation coefficients (ICC: .80 to .99) for intratester and intertester reliability for total AP and I-E have been reported. Measurement reliability of this instrument for one-way laxity is unknown. Due to the ankle complex being highly flexible around the neutral unloaded position, high variability in one-way measurement with repeated positioning can be expected. This indicates that the reliability of the system in measurement of total laxity should be higher than in measurement of one-way laxity. **Objective:** To determine the reliability of ankle arthrometry in the measurement of one-way and total AP and I-E laxity of the ankle complex. **Design:** Intratester reliability was examined using a test-retest design. **Setting:** Research laboratory. **Participants:** A total of 200 ankles from 100 subjects with no history of ankle injury (male: 50, female: 50; 21.8 ± 2.0 years, 76.3 ± 16.1 kg, 171.7 ± 7.7 cm). **Interventions:** AP and I-E load-displacement curves were collected using a manually controlled instrumented arthrometer (Blue Bay Research, Navarre, FL). All ankles underwent loading at 0° flexion, which was defined as the neutral unloaded position. This angle represents zero moment with repositioning, were performed on each ankle. **Main Outcome Measurements:** Laxity measurements included anterior, posterior and total AP displacement during loading at 125 N and inversion, eversion, and total I-E rotation during loading at 4-Nm. Intraclass correlation coefficients (ICC 2,1) were used to assess the reliability of the arthrometer in measurement of one-way and total laxity of the ankle complex. **Results:** The laxity data indicate high reliability in measurement for total AP laxity (Measurement 1 = 17.65 ± 4.9 mm and Measurement 2 = 17.86 ± 4.9 mm; ICC = .98) and total I-E laxity (Measurement 1 = 38.18 ± 10.4° and Measurement 2 = 38.35 ± 10.5°; ICC = .99). They also indicate that the reliability of the arthrometer in measurement of total laxity is higher than in measurement of one-way laxity (ICC = .88, anterior; .83, posterior; .96, inversion; and .95, eversion). **Conclusions:** Excellent correlations were observed for total AP laxity and for both one-way and total I-E laxity measures. Good to excellent correlations were observed for the one-way laxity measures of anterior and posterior laxity. Greater variation in the unloaded position with repeated positioning decreases the reliability of one-way AP laxity measurement more than one-way I-E laxity measurement.

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**Immediate Effects Of Posterior Talocrural Joint Mobilizations Following Acute Lateral Ankle Sprain**

Cosby NL, Grindstaff TL, Parente W, Hertel J: University of Virginia, Charlottesville, VA

**Context:** Dorsiflexion range of motion (ROM) is a common impairment following lateral ankle sprains. Restrictions in dorsiflexion ROM have been associated with a lack of posterior talar glide on the tibia in participants suffering from ankle sprain. Anterior to posterior (AP) mobilization of the talocrural joint is often indicated as a treatment in the case of an arthrokinematic restriction at the talocrural joint. **Objective:** To examine the effects of a single bout of AP joint mobilizations on self-reported function, dorsiflexion ROM, and posterior talar glide displacement in individuals with an acute lateral ankle sprain. **Design:** Single-blinded, randomized controlled clinical trial. **Subjects**: Seventeen physically active individuals (8 control, 9 treatment, mean age 19.76±1.35, mean height 69.10 ± 4.31cm, and mean mass 71.34±16.45 kg) with mild acute lateral ankle sprains, immobilized for a minimum of three, but a maximum of seven days, and an average of a 6.5°±1.33° dorsiflexion ROM deficit compared to the contralateral limb. **Intervention(s)**. The treatment group subjects

received a single 30-second bout of Grade III AP joint mobilizations on the day their immobilization device was removed, while the control group did not receive the mobilizations. **Main Outcome Measures**. Active dorsiflexion ROM, posterior talar displacement as assessed with an ankle arthrometer were assessed before, immediately after, and 24 hours after receipt of the treatment or control interventions. Self-reported function as assessed with the Foot and Ankle Ability Measure (FAAM) was assessed before and 24 hours after the receipt of the treatment or control interventions. **Results:** There were no significant group by time interactions or group main effects for dorsiflexion ROM (p=.85, p=.66, respectively) posterior talar displacement (p=.57, p=.51), or self-reported function (p=.52, p=.24). Significant main effects for time, however, were observed for dorsiflexion ROM (p=.037) and self-reported function (p=.004) indicating improvement over time across both groups, but not for posterior talar displacement (p=.434). Descriptive measures were as follows for dorsiflexion ROM (Control: pre=7.36±6.38º, immediate post=8.5±4.02º, 24 hours post=9.94±4.0º; Treatment pre=6.49±6.43º, immediate post=6.62±7.34º, and 24 hours post=8.82 ±7.29º), posterior talar displacement (Control: pre=5.86±2.81 mm, immediate post= 5.34±2.98 mm, 24 hours post= 6.95±3.64 cm; Treatment pre= 7.09±3.54 mm, immediate post= 6.86±3.69 mm, and 24 hours post= 7.06±2.99 mm), and self-reported function (Control: pre=72.76 ±18.73%, 24 hours post= 82.09 ±9.99%; Treatment pre= 62.29±17.63%, 24 hours post= 75.85± 15.15%). **Conclusion:** These finding suggest that a single bout of grade III anterior to posterior joint mobilizations following a lateral ankle sprain may not be effective at immediately increasing dorsiflexion ROM, posterior talar displacement, or self-reported function.

## EBF: Ankle & Foot

Wednesday, June 23, 2010, 12:15PM-1:15PM, Room 201C; Discussants: Tricia Hubbard, PhD, ATC, and Michael Dolan, MA, ATC; Moderator: Matthew Hoch, MS, ATC

## EBF: Education

Thursday, June 24, 2010, 8:15AM-9:15AM, Room 201C; Discussants: Stacy Walker, PhD, ATC, and John Parsons, MS, ATC; Moderator: S. Manspeaker

## Free Communications, Oral Presentations: Evidence-Based Strategies & Critical Thinking in Education

Thursday, June 24, 2010, 9:15AM-10:30AM, Room 201C; Moderator: Mark Larson, ATC

**Assessment Of Evidence-Based Practice Knowledge, Comfort, And Importance Levels Of Athletic Training Educators**

Welch CE, Van Lunen BL, Walker SE, Manspeaker SA, Hankemeier DA, Brown S, Laursen RM, Onate JA: Old Dominion University, Norfolk, VA; Ball State University, Muncie, IN; Boston University, Boston, MA

**Context:** Recognizing the current knowledge and understanding of evidence-based practice (EBP) concepts among athletic training educators (ATE) is required before formulation of new strategies and effective techniques for implementation of EBP into athletic training education curricula can occur. **Objective:** To assess ATEs' current knowledge, comfort, and importance levels in regard to evidence-based concepts. **Design:** Quasi-experimental survey design. **Setting:** Self-reported online survey via personal computer. **Patients or Other Participants:** 141 educators (28.3% response rate) from a convenience sample (age=38.38 ± 8.74, years of athletic training teaching experience=9.81 ± 7.19). **Interventions:** Participants were solicited via e-mail to complete the online *Evidence-Based Concepts for Clinical Practice Assessment* and demographic questionnaire. The instrument was created using Inquisite 8.0 Corporate Survey Builder. The survey consisted of the following: 20 multiple-choice knowledge questions, 22 Likert scale (range 1-4) questions assessing comfort (11) and importance (11), and 34 demographic questions. Independent variables included terminal degree, hours of academic work, patient care, and research per week, EBP workshops previously attended, and years of athletic training teaching experience. Reliability for the instrument was moderate to excellent (percent agreement: 3 questions=50%, 6 questions=66.7%, 7 questions=83.3%, 4 questions=100%). **Main Outcome Measures:** The dependent variables were the scores produced by survey responses. Knowledge scores were tabulated by awarding 1 point for the correct answer (max=20). The comfort and importance Likert section scores were achieved by totaling all values and then calculating the average value back to the Likert scale composite score (total divided by four). A higher score indicated the participants had a higher comfort level with EBP concepts and indicated the concepts were important for curricula implementation. Significant differences ($p<.05$) and correlations were calculated (SPSS 16.0) using independent/paired T-test, one-way/repeated measures ANOVA, Mann-Whitney U test, Wilcoxson signed-rank test, and Pearson/ Spearman correlations. **Results:** Overall EBP knowledge was 64.4%. Characteristics associated with higher knowledge scores were terminal degree (69.92% ± 10.36, $p<.001$), hours of research per week (66.96% ± 12.61, p=.029), and hours of academic work per week (67.47% ± 12.48, p=.002). Overall EBP comfort was 2.37/4.0 ("uncomfortable"). Characteristics associated with higher comfort scores were terminal degree (2.51 ± 0.67, p=.017), hours of research per week (2.52 ± 0.69, p=.025), and EBP workshops previously attended (2.56 ± 0.66, p=.002). Overall EBP importance was 3.34/4.0 ("important"). Characteristics associated with higher importance scores were hours of research per week (3.44 ± 0.45, p=.009). **Conclusions:** Athletic training educators' current knowledge of EBP concepts can be improved. ATEs are uncomfortable with evidence-based concepts, yet believe it is important for curricular implementation. The future development of workshops and teaching models should focus

on the varying levels of EBP concepts. Distinguishing modes for curricula implementation might also be an effective way to increase knowledge, comfort, and importance levels.

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**Implementation Of Evidence-Based Practice Concepts In Undergraduate Athletic Training Education: Experience Of Select Educators**

Manspeaker SA, Van Lunen BL: Old Dominion University, Norfolk, VA

**Context:** Entry-level athletic training education must transition toward instruction of evidence-based practice (EBP) in order to maintain progress with other health professions' clinical practices and educational standards. **Objective:** To evaluate instructors' experience with implementation of evidence-based practice concepts in Commission on Accreditation of Athletic Training Education (CAATE) entry-level athletic training education programs to establish the current state of instructional approaches. **Design:** Interviews of emergent design with elements of phenomenology and modified-grounded theory. **Setting:** CAATE accredited undergraduate athletic training programs. **Participants:** Eleven educators (3 males, 8 females; average years teaching 14.73, SD=7.06) were interviewed to evaluate their experience and perceptions of implementation of evidence-based concepts within their education programs and courses. **Data Collection and Analysis:** Instructors' experience regarding teaching of these concepts was explored qualitatively through coding by the researcher. Constant comparison lent to the confirmation of the emerging theories and analysis of patterns. Established categories were triangulated and member checked to establish trustworthiness of the findings. **Results:** The analysis determined that educators have three primary approaches to evidence-based practice concept implementation within their programs: curricular emphasis, teaching strategies, and student activities. Educators accomplish curricular emphasis through faculty support, programmatic meetings, and EBP concept implementation. Teaching strategies included class preparation, presentation style, and objectives for concept implementation that transcended the cognitive levels of the revised Bloom's taxonomy. Student activities were described through methods self-discovery, finding and evaluating the literature, and clinical practice. **Conclusions:** Athletic training educators who integrate EBP into curricula are utilizing multiple avenues of inclusion through programmatic objectives and courses already in existence. The teaching objectives, strategies, and activities presented should provide educators with a foundation to initiate evidence-based instruction within their own programs. As future National Athletic Trainers' Association Educational Competencies will most likely include EBP concepts, instructors should be proactive in placing this information within didactic curriculum and encourage its use during clinical experience.

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**The Importance Of Critical Thinking Dispositions To Success In Athletic Training Education**

Sipes RC, McLoda TA, Broadbear JT: Illinois State University, Normal, IL, and University of Wisconsin Oshkosh, Oshkosh, WI

**Context:** Athletic training students learn to analyze situations and solve problems to be successful. Critical thinking is an important skill for completion of these tasks but has not been studied thoroughly in athletic training education. **Objective**: The purposes of this research were to study whether critical thinking dispositions changed over time in an ATEP and to investigate whether dispositions are associated with success on the new format of the BOC examination. **Design:** Prospective cohort. **Setting**: Students involved in a CAATE accredited ATEP. The BOC examination and the California Critical Thinking Dispositions Inventory (CCTDI) were used and have been shown to be valid and reliable. The CCTDI measures 7 dispositions (truthseeking, openmindedness, inquisitiveness, analyticity, systematicity, maturity, and self-confidence) on a 60 point scale for a total possible score of 420. **Participants**: Convenience sample of 16 ATEP students (9M/7F; 23.16±1.55 years). **Interventions:** Participants completed the CCTDI measure upon entry into the program and just before graduation. They were then grouped according to gender and BOC exam success (first-time pass vs. fail) to describe differences in dispositions. **Main Outcome Measures**: Independent samples t-tests were analyzed for differences on both total CCTDI scores and the dispositional subscales for gender and BOC success. A paired samples t-test was used to compare pretest/posttest data. A priori alpha level was set at $p<.05$. **Results**: Only the truthseeking disposition changed over-time in an ATEP, with an average increase of 4.96 points (pre:36.60±6.24; post:39.56±3.95; t=2.32; p=.035). Total CCTDI scores showed no significant differences by gender [pre(males:281.56 ±27.27; females: 304.00± 20.63; t=1.874; p=.082); post(males:293.00 ±21.07; females:301.29±15.48; t=.906; p=.380)]; however, female students scored higher in both the maturity [pre(males:37.56±5.41; females:46.14±4.60; t=3.428; p=.004); post(males:41.67±5.17; females:47.00±2.83; t=2.629; p=.021)] and openmindedness [pre(males:39.33±4.80; females:44.57±4.08; t=2.359; p=.034); post (males:38.33±3.94; females:43.43±3.10; t=2.896; p=.012)] dispositions for both pretest and posttest measurements. Participants had a first time pass rate of 62.5% (n=10) and the passing group scored 7.53 points lower on pretest systematicity (pass:37.80±5.65; fail:45.33±4.41; t=-2.97; p=.011), 4.37 points lower on posttest systematicity (pass:37.80±3.88; fail:42.17±3.37; t=-2.39; p=.036), and 18.47 points lower on the posttest total score (pass:289.70±17.70; fail:308.17±15.25; t=-2.21; p=.048). **Conclusions**: Critical thinking dispositions remained relatively stable while engaged in the ATEP, but truthseeking increased while in the ATEP. Females were more likely to display the openmindedness and maturity dispositions, but only the systematicity disposition was linked to BOC exam results. Those passing had a lower total disposition score on posttest results. **Practical Applications:** This information informs ATEP personnel that critical thinking dispositions are not affected by program matriculation but may be founded prior to program entry. Strong critical thinking dispositions were not associated with success on the BOC exam, but instead those who passed on the first attempt scored lower on posttest total CCTDI score as well as both systematicity scores.

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**Do Didactic Educational Strategies Improve Clinical Decision Making Skills Of Entry Level Students In Medicine And Allied Health Care Professions? A Systematic Review**

Vela LI, Heinerichs S: Texas State University, San Marcos, TX, and West Chester University, West Chester, PA

**Context:** Clinical reasoning is a cognitive process that results in clinical decisions that integrate research, patient values and clinician expertise. Enhancing student clinical decision making ability should be an important objective of athletic training education. **Objective:** To answer the clinical question, "Do didactic educational strategies improve clinical decision making skills of entry-level students?" **Data Sources:** We searched ERIC, Medline, CINAHL, Sports Discus, and Education Research Complete databases between 1975 to November 2009 using the terms clinical reasoning and clinical decision making, learn* and clinical reasoning, and learn* and clinical decision making resulting in a total of 512 articles. **Study Selection:** Studies that met six criteria were included: 1)

experimental or quasi-experimental design, 2) didactic setting, 3) clearly defined teaching strategy, 4) students in the allied health or medical profession, 5) entry-level professional education, and 6) outcomes reported on clinical decision making. **Data Extraction:** Two authors independently assessed the articles using a modified *Evaluation of Quality of an Intervention Study* (EQIS) developed by MacDermid, 2003. The modified scale contains 12 items and scores range from 0-24 points with a higher score signifying a better score. We reached a consensus score when disputes arose. We calculated Cohens d effect size (ES) and 95% confidence intervals (CI) for the difference in clinical decision making outcomes when means and standard deviation were reported. A positive ES indicated better clinical decision making outcomes for the experimental group. **Data Synthesis:** Seventeen articles were included for analysis. Educational interventions fell into one of 4 groups: peer learning, computer aided instruction (CAI)/ simulation, problem based learning (PBL), and reasoning strategies. The average EQIS score was 12.5±3.0 (range: 9-18). ES point estimates and CIs were calculated for 9 articles and CIs crossed the zero point for all but 2 studies. Students using a diagnosis/backwards reasoning strategy demonstrated fewer errors (d= 0.52, 95% CI=.012 to 1.16) with a moderate ES and identified fewer irrelevant patient features (d= 2.09, 95% CI =1.85 to 2.33) with a large ES. Students using CAI for PBL had higher mean scores on 4 clinical reasoning (CR) problems (CR1d=8.25, 95% CI=7.98 to 8.46; CR2 d=8.57, 95% CI =8.36 to 8.83; CR3 d=13.50, 95% CI=13.28 to 13.80; CR4 d=12.76, 95% CI =12.55 to 13.02) indicating large effects. **Conclusions:** A diagnosis/backwards reasoning strategy and PBL using CAI were superior to other interventions in this review. The educational strategies, outcome assessed and sample sizes varied and could have attributed to the findings. Scores on the EQIS were typically low and many studies did not provide the necessary data to calculate ES. No studies were performed with athletic training students. There is a need for a rigorous, well designed study of athletic training students and clinical decision making interventions.

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**Studymate® as an Educational Tool Improves Athletic Training Students' Learning in a Therapeutic Modality Course**

Berry DC, Berry LM: Weber State University, Ogden, UT

**Context:** Learning activities like crossword puzzles, word searches, and computer games such as Jeopardy® and Online Flashcards reinforce and motivate student learning. StudyMate® (Respondus, Inc, Redmond, WA) is another example of a learning tool using a variety of electronic activities to reinforce learning. However, StudyMate® has not been examined within athletic training to provide evidence for its use as a pedagogical tool. **Objective:** To examine the effectiveness of StudyMate® as a pedagogical tool to improve student learning outcomes. **Design:** Pre-post test study. **Setting:** University classroom setting. **Participants:** Thirty-six undergraduate athletic training and therapy students (males = 22, females = 14; 24.5 ± 3.9 years of age) enrolled in two separate therapeutic modality courses taught by the same instructor participated in the study. **Interventions:** One class was designated the treatment (StudyMate®) group (n=18) and the other class the control group (n=18). The treatment group was provided access to the StudyMate® files designed by the instructor. Eighty-five terms/concepts related to wound healing considered important by the instructor were used to construct the StudyMate® program. Students were required to spend a minimum of 60 minutes and attempt each activity within a week. StudyMate® activities included: (1) Flashcards, (2) Pick-a-Letter, (3) Fill-In-the-Blank, (4) Matching, and (5) Crossword Puzzles. The control group received no access to the program. Each group received identical lectures, handouts, and other classroom assignments/activities. **Main Outcome Measures:** Pre and post exam scores, time to complete the exam, and study time were recorded in both groups. Repeated measures of analysis of variance (ANOVA) with between-subjects (group) and within-subjects (time) effects assessed pre-post changes in exam score and time needed to complete the exam. Independent *t*-tests analyzed time dedicated to preparing for the exam (perceived hours studied). To ensure equivalency between groups prior to initiating the study, independent *t*-tests were performed between the control and treatment groups on pre-test exam score and time to complete the exam. **Results:** Repeated-measures ANOVA revealed significant differences in the post-exam scores between the groups ($F_{1,34} = 5.39$, $P = .027$). The treatment group demonstrated a higher post-exam score (84.5% ± 7.5%) compared to the control group (74.6% ±11.2%). No significant difference was noted between time needed to complete the exam ($F_{1,34} = .32$, $P = .858$). Independent *t*-test revealed no difference between perceived time spent studying for the exam ($t$=.754, $P$ = .456). **Conclusions:** The results of the study indicate that using the StudyMate® program as a course learning activity demonstrated a positive effect on student learning outcomes. As a pedagogical tool, StudyMate® offers students another viable option toward learning and exam preparation. Further research needs to examine the effects of StudyMate® on learning using a larger sample size and other content areas.

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# Free Communications, Oral Presentations: Professional Development & Preparation in A.T.

Thursday, June 24, 2010, 10:45AM-11:30AM, Room 201C; Moderator: Jim Mensch, PhD, ATC

**Perceptions Of Preparation For Job-Specific Duties Of Athletic Trainers In The Professional Baseball Setting**

Gardiner-Shires AM, Marley SC, Barnes JC, Shires ME: The University of New Mexico, Albuquerque, NM; West Chester University,West Chester, PA; Baltimore Orioles, Baltimore, MD

**Context:** Baseball athletic trainers (BATs) have a unique role as administrators. Their perceptions of job preparation may shed light on the quality of specific educational experiences. **Objectives:** 1) Determine retrospective perception of academic preparation for job-specific duties performed by BATs, 2) Determine perception of current skills at job-specific duties, and 3) Determine whether preparation experiences (e.g., internships, work experience, etc.) interact with perceived retrospective and current skills. **Design:** A retrospective pretest-posttest design. **Setting:** Online survey. **Participants:** 275 BATs with 180 (65%) completing the survey. 178 (98.9%) were male and the mean age was 34.57 years (*SD* = 8.12 years). The mean number of years employed in professional baseball excluding their internship was 10.26 years (*SD* = 8.71 years). **Interventions:** The survey asked respondents to report their level of preparation prior to beginning their position and their current skill in the following domains: Evaluation of shoulder, elbow, and other conditions, acute care, prevention, conditioning, treatment, rehabilitation and reconditioning, organization and administration, and baseball specific non-health care related tasks. Each domain was measured with job task statements that were developed using the current NATA Educational Competencies, BOC Role Delineation Study, and BATs job descriptions. Subscale reliabilities were calculated and found to be between .80 and .90. **Main Outcome Measures:** Repeated-measures analyses of covariance were performed with each perception of preparation (retrospective vs. current) as a within-subjects factor. Preparation experiences (e.g., internships and work experience) were included as between-subjects factors. Of specific interest was the interaction of the between-subjects factors with the within-subjects factor. **Results:** Due to space limitations notable results are described. The results indicated that athletic trainers who completed internships had higher retrospective perceptions of skill relative to those who had not in evaluation of shoulder injuries (adjusted *Ms* = 71% and 64%, $p = .04$), treatment techniques (*Ms* = 72% and 66%, $p = .04$), and non-health care related tasks (*Ms* = 66% and 52%, $p = .01$). Athletic trainers with prior work experience had greater retrospective perceptions of preparation to perform elbow (*Ms* = 81% and 69%, $p = .03$) and shoulder (*Ms* = 71% and 65%, $p = .04$) evaluations relative to those without. Completion of a graduate assistantship was not a significant predictor of any of the skills. No group-related differences were observed on present skill perceptions ($p > .05$). **Conclusions:** Athletic trainers who completed an internship or had prior work experience reported higher perceptions of job-related skills relative to others. The lack of statistical differences on the post test measures of current skill suggests that on-the-job experiences may mitigate advantages associated with internship and work experiences.

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**Exploration Of The Benefits Of Informal Continuing Education In Athletic Training**

Armstrong KJ, Weidner TG, Walker SE: Georgia College & State University, Milledgeville, GA, and Ball State University, Muncie, IN

**Context:** Informal continuing education (CE) activities (i.e., not approved for CE credit) are perceived to improve clinical skills or abilities and attitudes towards patient care more than formal CE activities (i.e., approved for CE credit). However, no research has been conducted to understand why the informal CE activities are beneficial to athletic training practice. **Objective:** To explore athletic trainers (ATs) rationale for engagement in, perceived benefits of, and suggestions regarding informal CE activities which should be considered for CE credit. **Design:** Descriptive qualitative method of inquiry with a grounded theory approach. **Setting:** Focus groups were conducted at the 2009 National Athletic Trainers' Association (NATA) Annual Meeting and Clinical Symposium. **Patients or Other Participants:** Athletic trainers pre-registered for the 2009 NATA Annual Meeting and Clinical Symposia were stratified by NATA district. Invitations to participate in a focus group were sent to 100 randomly selected pre-registrants, proportional to district memberships. A total of 14 ATs (5 males, 9 females; 7.8 $\pm$ *5.56* years experience as an AT) from 6 athletic training practice settings (i.e., college/university, high school, clinic, orthopedic physician's office) participated in one of two scheduled focus groups. Group responses were solicited until no new information was being provided (i.e., data saturation). **Data Collection and Analysis:** Focus group comments were recorded, transcribed verbatim and analyzed inductively using an interpretative coding method. Three researchers independently identified specific themes and categories. Trustworthiness and accuracy of themes and categories were established through data analyst triangulation amongst the three researchers. **Results:** Overall, the rationale for engaging in informal CE activities included that they improved professional practice because the activities were guided by actual patient care needs, were of personal interest to the practitioner, and were easily accessible. Three themes also emerged regarding why informal CE activities are beneficial to AT practice: transferability to patient care, meets the participant's learning needs, and encourages thoughtful and reflective AT practice. Participants suggested a variety of informal CE activities related to professional development (e.g., participating in journal clubs) and professional service (e.g., serving as an approved clinical instructor) which should be awarded CE credit. **Conclusions:** ATs engage in informal CE activities because these educational activities enhance patient care. Also, because of the personal investment of the AT with regards to their rationale for selecting and participating in informal CE activities, these activities seem to particularly meet practitioner learning needs. It appears that awarding CE credit for informal CE activities may be warranted.

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**Various Factors Affect Athletic Trainers' Selection Of Continuing Education**

Walker SE, Armstrong KJ, Berry DC, Samdperil G, Hughes BJ, McGuine T, Penny JM: Ball State University, Muncie, IN; Georgia College & State University, Milledgeville GA; Weber State University, Ogden, UT; Sacred Heart University, Fairfield, CT; University of Central Missouri, Warrensburg, MO; UW Health Sports Medicine Center, University Research Associates, Madison, WI

**Context:** Continuing education (CE) is a lifelong learning process for all health care

practitioners including athletic trainers (ATs). However, it is unclear how ATs select their CE. An understanding of the factors regarding the selection of CE activities could enhance the overall delivery of CE. **Objective:** To identify what factors affect ATs selection of CE activities. **Design:** Descriptive qualitative method of inquiry with a grounded theory approach. **Setting:** Focus groups were conducted during the 2008 National Athletic Trainers' Association (NATA) Annual Meeting and Clinical Symposia. **Patients or Other Participants:** Athletic trainers pre-registered for the 2008 NATA Annual Meeting and Clinical Symposia were randomly stratified by NATA district. The number of those included in the stratified random sample was inflated to account for a 33% rate of participation and a 25% no-show rate to the focus groups. Invitations to participate in focus groups were sent to 1,923 ATs. A total of 113 (69 males, 45 females) individuals participated in seven focus groups. Participants had 15.8 ± 9.8 years of experience as an AT, represented all NATA districts, and represented 13 different practice settings (e.g., secondary high school, clinic/hospital, higher education). Group responses were solicited until data saturation occurred. **Data Collection and Analysis:** Focus group comments were recorded, and transcribed verbatim. Interpretive open coding was used to identify themes and sub-themes from individual responses. Data analysis was completed by two independent analysts to identify themes and sub-themes. Peer review strategies were used to ensure trustworthiness and accuracy of themes and sub-themes identified. **Results:** Overall, the selection of CE is based on a variety of factors which differ between each individual practitioner. Participant comments regarding the selection of CE were summarized into 3 main themes: 1) learning needs of the AT (e.g., providing evidence-based patient care, knowledge presented applicable to current patient needs), 2) attributes of the CE activity (e.g., delivery format, location and/or length of CE activity, reputation of speaker), and 3) associated travel expenses (e.g., cost of CE activity, reimbursement from employer, paid leave from employer, associate cost of family travel). **Conclusions:** It appears that no single factor solely affects an ATs selection of CE. Although highly individualized, selecting CE activities that meet the learning needs of the AT was the most predominant factor regarding the selection of CE. CE providers are encouraged to continue to offer a broad variety of educational topics via differing delivery modes (e.g., lecture, group discussion, hands-on workshops, online courses, etc.) to best meet the CE needs of ATs.

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# Free Communications, Oral Presentations: Acute Concussion Assessment

Thursday, June 24, 2010, 4:30PM-5:45PM, Room 201C; Moderator: Steve Broglio, PhD, ATC

### Representative Baseline Values And Gender Differences On The Sport Concussion Assessment Tool 2 (SCAT2) In Adolescent Athletes

Capili BJ, Dickey A, Mathieson K, Valovich McLeod TC: A.T. Still University, Mesa, AZ

**Context:** In an effort to improve and standardize the sideline evaluation of sport-related concussion, the SCAT2 was recently developed. This tool assesses concussion-related signs and symptoms, cognition, balance, and coordination. As this is a newly-published assessment tool, representative baseline data on adolescent athletes has not yet been established. **Objective:** To determine representative baseline SCAT2 scores in adolescent athletes and to examine whether gender differences exist on the SCAT2. **Design:** Descriptive, cross-sectional. **Setting:** High school sports medicine facilities. **Participants:** Male (n=157, age=15.1±2.8 years, grade=9.9±1.0 level) and female (n=76, age=15.1±1.1 years, grade=10.1±1.1 level) athletes participating on interscholastic athletic teams during the fall preseason. **Interventions:** Participants were administered the SCAT2, which 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. The SAC and BESS components of the SCAT2 have demonstrated acceptable reliability and validity. Overall representative values were analyzed using descriptive statistics. Independent t-tests, with gender as the independent variable, were conducted to assess differences in SCAT2 total and component scores between males and females ($p<.05$). No adjustments were made for multiplicity as these were exploratory analyses. **Main Outcome Measures:** Dependent variables included the SCAT2 total score, and the component scores for symptom scale (/22), sign score (/2), GCS (/15), SAC (/30), BESS (/30), and coordination score (/1). Lower scores on the SCAT2 and each component score indicate greater deficits. **Results:** The SCAT2 total score across all subjects was 85.7±6.9 (range=62-99, skewness=-.42±.16, kurtosis=-.33±.32). Representative component scores were also derived for the symptom score (15.1±5.6), sign score (2.0±0.0), GCS score (15.0±0.0), SAC (26.1±2.7), BESS (26.6±2.6) and coordination score (1.0±0.0). There were no differences between males and females on the SCAT2 total score (p=.22, male=85.3±6.7, female=86.5±7.3), symptom score (p=.81, male=14.8±5.4, female=15.0±5.9), and BESS (p=.37, males=26.4±2.5, female=26.8±2.8). Females (26.6±2.2) scored significantly higher (p=.042) on the SAC compared to males (25.8±2.9). Gender analyses of the sign score, GCS score, and coordination score were not performed due to the absence of variability in the scores. **Conclusions:** These data provide the first insight into representative scores on the SCAT2 in adolescent athletes and demonstrate that males and females do not differ on SCAT2 score at baseline. Variability in baseline SCAT2 scores was due to the symptom score, SAC, and BESS. These values suggest that otherwise healthy adolescent athletes display variability at baseline. Therefore it is recommended that clinicians administer baseline assessments of the SCAT2, as relying on a perfect baseline score of 100 points is not appropriate in an adolescent athlete population.

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### Acute Post-Concussion Deficits On The Sport Concussion Assessment Tool 2 (SCAT2) In High School Athletes

Dickey AL, Capili BJ, Mathieson K, Valovich McLeod TC: A.T. Still University, Mesa, AZ

**Context:** The SCAT2 was recently 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 in the days immediately following a concussive injury. **Objective:** To investigate SCAT2 scores in high school athletes in the immediate days post-concussion. **Design:** Within-subjects, repeated measures. **Setting:** High school

athletic training facilities. **Participants:** 47 (46 males, 1 female, age=15.2±.9, grade =10.1±1.0 level) high school athletes who sustained a sport-related concussion diagnosed by their athletic trainer. **Interventions:** Participants were administered the SCAT2 on the day of injury (DOI) and day 3 post-injury (D3). 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, with scores ranging from 0-100 points. The SAC and BESS components of the SCAT2 have demonstrated acceptable reliability and validity. The independent variable was day. Paired t-tests were used to analyze the total SCAT2 score ($p<.05$) and each of the SCAT2 component scores (Bonferroni-adjusted $p\leq.008$). **Main Outcome Measures:** Dependent variables included the SCAT2 total score and the component scores for symptom score, sign score, GCS, SAC, BESS, and coordination score. Lower scores on the SCAT2 and each component score indicate greater deficits. **Results:** The DOI and D3 assessments were administered at 0.5±1.1 days and 3.8±1.7 days post-injury, respectively. Athletes returned to play 10.7±6.2 days post-injury. Significant differences between days were noted for the SCAT2 total score ($p<.001$) with DOI significantly lower (70.7±12.3) than D3 (78.5±10.1). Significantly lower component scores on DOI for the symptom score ($p=.001$; DOI=9.2±5.7, D3=13.3±6.8), sign score ($p<.001$, DOI=1.5±0.6, D3+1.9±0.3), and SAC ($p=.007$, DOI=23.3±5.2, D3=25.5 ±2.7) were also noted. No differences between days existed for the GCS ($p=.168$, DOI=14.8±0.6, D3=15.0±0.0), BESS ($p=.109$, DOI=20.5±6.4, D3=22.0±5.7), or coordination score ($p=.160$, DOI=0.9±0.3, D3=0.8±.04). **Conclusions:** Lower SCAT2 scores were found on DOI compared to D3, mainly resulting from lower symptom and cognitive scores. These findings indicate greater concussion-related impairments in symptoms and cognition in high school athletes immediately following concussion with some resolution by day 3 post-injury. The SCAT2 seems sensitive to detecting these impairments in high school athletes. It is recommended, however, that healthy, baseline scores be obtained to improve the interpretation and comparison of the post-injury scores and determine how long these impairments may last following a concussion. **Funding provided by a grant from the National Headache Foundation.**

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**Corroborative Factorial Evidence For Responses To A Self-Report Concussion Symptom Scale**

Piland SG, Byon KK, Ferrara MS, Lee HR, Resch JE, Gould TE: The University of Southern Mississippi, Hattiesburg, MS, and The University of Georgia, Athens, GA

**Context:** It has been recognized that self-report concussion symptom scales have developed from an evolutionary process instead of being developed from *a priori* theory through psychometrically sound and rigorous processes. Thus, post hoc efforts have been made to provide understanding regarding the validity of responses to such instruments. Currently, strong evidence exists to support the factorial validity of an underlying three-factor response structure to baseline responses, but no such evidence is available to support responses of concussed athletes to the same instrument. Since post injury composite scores of such instruments are used for comparison to baseline composite scores (as a part of a multi-faceted approach for making return to play decisions) it is important that underlying response structures to measures across the populations of concussed and non-concussed respondents be demonstrated invariant. **Objective:** The purpose of this study was to corroborate the response structure of the Head Injury Scale-revised (HIS-r) on a clinical population of 46 concussed athletes. **Design:** A retrospective, cross-sectional design involving a single testing session. **Setting:** Data was collected in a laboratory located at a southeastern Division I institution. **Patients or Other Participants:** The group was comprised of athletes diagnosed with the brain injury of concussion (male n=34, age= 19.71±1.82, female n=12, age=20±1.21). **Interventions:** Each subject completed a health history questionnaire and the duration and severity components of the HIS-r. Participants were evaluated 24-hours following injury. **Main Outcome Measures:** Confirmatory Factor Analysis (CFA) using Maximum Likelihood (ML) estimation method was employed to examine an *a priori* three-factor measurement model. Model adequacy was tested via model fit and the magnitude of parameter estimations. Cronbach's $\alpha$ values were also calculated. **Results:** CFA indicated the initial three-factor model showed reasonable model fit [$\chi^2 = 41.51$, $\chi^2/df = 1.73$, CFI = .85, RMSEA = .126 (95%CI = .056 - .189), and SRMR = .102]. Given the low sample size of the current study, this model fit shows promising results. Cronbach's $\alpha$ show that all calculated values were above a .70 threshold. **Conclusions:** Obtaining and interpreting baseline and post-injury (follow-up) responses to summative self-report symptom scales is a recommended and vital part of the multi-faceted approach to injury assessment and management. Therefore, to be assured that the construct being measured (concussion) is consistent across conditions, it is imperative to confirm the factorial validity of the underlying structure of responses from each phase of assessment (baseline/concussed). This preliminary study provides initial corroborative evidence to support such invariance of responses before and after a concussion, which may serve to enhance the confidence of the sports medicine clinicians comparing follow-up responses to the HIS-r to baseline responses. Our findings also indicate the need for further study utilizing robustly sized samples.

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**Influence Of Previous Concussion History On Knowledge, Attitude, And Reporting Of Concussion In High School Athletes: A Preliminary Analysis**

Register-Mihalik JK, Linnan L, Marshall SW, Valovich McLeod TK, Mueller FO, Guskiewicz KM: The University of North Carolina, Chapel Hill, NC, and A.T. Still University, Mesa, AZ

**Context:** Literature has identified limited concussion symptom knowledge, issues with previous concussions, and problems with reporting of concussion in high school athletes. Few studies have addressed the influence previous concussion history has on knowledge, attitude, and behavior regarding concussion in these athletes. **Objective:** To determine the association between number of previous concussions and reporting of concussion in a sample of high school athletes; and to assess differences in attitude toward concussion reporting and knowledge of concussion concepts among high school athletes across 3 concussion history groups (tertiles= lowest, moderate, and highest numbers of previous concussions in the sample). **Design**: Cross-sectional survey design. **Setting:** The survey instrument was completed at the athletes' home. **Patients or Other Participants:** A convenience sample of 10 high schools and 84 athletes participating in cheerleading, football, boys/girls soccer, and/or boys/girls lacrosse from the Eastern United States (age=15.69±1.14 years). **Interventions:** Athletes attended a meeting at each school and received a packet containing the survey instrument and consent documents to take home, complete, and return. Kappa Agreement for questions (all yes/no) included in the knowledge total score (KTS) was 0.6-1.0 and reliability of the Likert score responses

included in the attitude total score (ATS) was $ICC_{2,1} \geq 0.6$. Independent variables included the number of self-reported previous concussions, and grouped concussion history (tertiles). **Outcome Measures:** Reporting of concussion, which was defined as saying yes/no to reporting all self-identified concussions to a coach or medical professional during the athlete's high school years; ATS (total of the 14 attitude Likert score answers); and KTS (number of questions correct out of 35) served as outcome measures. A generalized estimating equation with naïve standard error was used to examine the association between the number of self-reported previous concussions and reporting of concussion. Two separate random intercepts general linear mixed models were used to examine differences between concussion history groups regarding ATS and KTS. All analyses accounted for clustered school data. **Results**: Athletes with a more pronounced concussion history were less likely to report possible concussions to a medical professional or a coach (Wald = 4.76;$P$=0.03). There was a significant difference among concussion history groups regarding ATS ($F_{2,8}$=23.78;$P$<.001), with overall attitude being more favorable in individuals experiencing the least number of previous concussions (86.04±8.79) compared to individuals with the moderate (77.06±7.86) and the highest (77.68±9.73) number of previous concussions. There was no difference among the concussion history groups regarding KTS ($F_{2,9}$=1.43;$P$=0.29). **Conclusions:** Athletes with previous concussions may have a more negative attitude towards concussion reporting and appear less likely to report possible concussions. Clinicians should be more cautious with individuals who have more pronounced concussion histories in an effort to indentify possible injuries that may not be reported by the athlete.

**Predictors of Symptom Resolution Following Sport-Related Concussion**

Resch JE, Lee HR, Brown CN, Baumgartner TA, Olejnik S, Walpert K, Macciocchi SN, Ferrara MS: University of Georgia, Athens, GA; Georgia Neurological Surgery, Athens, GA; Shepherd Center, Atlanta, GA

**Context:** Resolution of sport-related concussion symptoms typically takes 7 to10 days. An athlete's recovery may deviate significantly due to multiple factors such as prior history of concussion and current concussion severity. While there is variability in symptom resolution following concussion, a prediction equation may assist athletic trainers in estimating time until self-reported asymptomatic (SRA) following a concussion. **Objective:** Examine a multivariate regression model to predict SRA in a collegiate athlete sample. **Setting:** Athletic Training Laboratory **Design:** Cross-sectional study from the 2004 – 2009 sport seasons. **Patients or Other Participants:** Forty-four collegiate athletes diagnosed as concussed (32 males, 12 females): age 19.81 ± 1.6 years. **Interventions:** Participants were evaluated 24 hours post-injury utilizing a self-reported symptom inventory, ImPACT, and the Neurocom Sensory Organization Test (SOT). Time until SRA was defined as number of days between athletes' 24 hours post-concussion assessment and when athletes reported asymptomatic. Multiple regression analysis was performed utilizing the stepwise selection method. Significant relationships between predictors and the criterion were determined with = .05. **Main Outcome Measures:** Twenty-two self-reported symptoms ranked on severity and duration; composite, somato-sensory, vestibular, visual, and visual conflict scores from the SOT; and the ImPACT composite scores visual and verbal memory, visual motor reaction time, reaction time, impulse control and symptoms were used as predictors, and time until SRA as the criterion. **Results:** Average SRA was 8.50 ± 3.9 days. The linear model was time until SRA = 15.968 + (-.128 x ImPACT composite score visual memory) + (.927 x severity of sensitivity to noise) + (.737 x severity of blurred vision) + (-.915 x duration of irritability) + (-2.089 x nervousness) which was statistically significant, ($R$ = .749, , $R^2_{adjusted}$ = .499, $F_{(5,41)}$ = 9.175, $P \leq$ .001, $SE$ = 2.771, $R^2_{cv}$ = .46).The strongest predictor to criterion relationships were between the ImPACT subscore visual memory ($R$ = -.437, $R^2$=.190, $R^2_{change}$ = .191, $P$ < .001), severity of blurred vision ($R$ = .420, $R^2$=.176, $R^2_{change}$ = .070, $P$ < .001) and sensitivity to noise ($R$ = .381, $R^2$=.145, $R^2_{change}$ = .168, $P$ < .001). The weaker predictor to criterion relationships were duration of irritability ($R$ = .028, $R^2$=.001, $R^2_{change}$ = .070) and nervousness ($R$ = -.110, $R^2$=.012, $R^2_{change}$ = .062, $P$ = .03). **Conclusions:** Overall, this prediction model accounted for approximately 50% of variance associated with time until SRA. Given its components; the current model supports the use of a battery of tests to assess sport-related concussion. The current model, although specific to the University of Georgia concussion paradigm may be used to estimate time until SRA in individual athletes, but cross-validation of the current model with a larger sample of concussed collegiate athletes is warranted.

## EBF: Modalities

Friday, June 25, 2010, 10:00AM-11:00AM, Room 201C; Discussants : Jeremy Hawkins, PhD, ATC, and Jody Brucker, PhD, ATC; Moderator: C. Rubertino-Shearer

**Dose-Response Effects Of Phototherapy On Microcirculation In The Forearm**


Larkin KA, Martin JS, Zeanah E, Parr JJ, Braith RW, Borsa PA: University of Florida, Gainesville, FL


**Context:** Phototherapy is purported to improve blood flow to soft tissues. Modulating limb blood flow by increasing vasodilation in the microcirculation would be beneficial to healing by controlling edema, ischemia and the zone of necrotic tissue. This would create a favorable environment for an orderly biological repair process. However, no studies have directly examined the quantitative vasodilatory effect of phototherapeutic modalities clinically. **Objective:** To determine a therapeutic dose-response using a class IV laser that will enhance vasodilation and microcirculatory blood flow to the soft tissues in the forearm. **Design:** Cross-over repeated measures design where each subject serves as their own control and receives each treatment. **Setting:** Controlled laboratory setting. **Patients or Other Participants:** Ten healthy untrained college-aged male participants (20.8±2.16 yrs, 177.93±3.38 cm, 73.64±9.10 kg) with no current history of injury to the upper extremity, or current pathology that would compromise microcirculatory blood flow to the forearm. **Interventions:** A commercially available FDA approved Class IV phototherapeutic device (K®-Laser, Laser Therapy Products) was used in a light touch grid pattern covering the muscle belly of the biceps brachii. Each grid point was treated for 3-4 seconds (total treatment time 4 minutes). Each subject received 4 different doses of phototherapy treatment, sham (0Joules), 1watt (180Joules), 3watt (360Joules), and 6watt (720Joules) during four separate testing sessions. **Main Outcome Measures:** The dependent variables were changes in microcirculatory blood flow, measured using a VOP (EC-6, D.E. Hokanson, Inc.) and calibrated mercury strain-gauges. Statistical tests included a repeated measures ANOVA design to analyze changes in blood flow during treatments with phototherapy at 2, 3 and 4 minutes, as well as 1, 2, 3, 4 and 5 minutes post-treatment. The Huynh-Feldt test was used to examine differences over time. **Results:** The three watt group showed significance from baseline over time ($F=3.468$, $df=4.876$, $p<0.011$,). More specifically, there was a significant increase in blood flow from baseline when compared to the fourth minute of treatment (2.417±0.342 vs. 2.794±0.351, $p=0.032$). There were also significant increases post-treatment at 1 minute (2.767±0.358, $p<0.01$) and 2 minutes (2.657±0.369, $p=0.022$).By 3 minutes post-treatment blood flow had returned to normal. The sham, one watt and six watt group did not show significance from baseline at any time point However, the sham group did demonstrate similar changes in micro-circulatory blood flow to the one watt group. This illustrates a possible placebo effect as a result of subject expectancy when using the sham treatment. **Conclusions:** Our findings implicate class IV phototherapy at the 3 watt setting as an effective non-invasive treatment modality for health care providers to enhance microcirculatory blood flow in soft tissues. Phototherapy at one and six watts appears to be outside the ideal dosing window to provide physiological changes and therapeutic effects.

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**Triceps Surae Cooling Time Is Greater When Ice Bag Is Applied During Treadmill Walking**


Guzzo SJ, Carr JS, Demchak TJ, Yeargin SW, Edwards JE: Indiana State University, Terre Haute, IN, and Becker College, Leicester, MA


**Context:** Researchers have reported that walking for 30 minutes with an ice bag on the Triceps surae(TS) negates intramuscular (IM) cooling. However, many athletes may only walk a short distance and then rest and not walk for the full 30-minutes. **Objective:** To develop possible treatment parameters for ice bag treatment to the TS to more closely mimic clinical practice. **Design:** A within subject crossover design. **Setting:** Exercise Physiology Laboratory (~73 F). **Participants:** 9 healthy, physically active volunteers ( 24±2 y, 174.0±7.6cm, 86.3±6.5kg, triceps surae girth- right 40.3±1.2cm and left 40.8±1.3cm, and triceps surae skinfold- right 40.3±1.2cm and left 40.8±1.3cm). **Interventions:** All participants underwent three conditions on separate days: rest (no walking; R), walking for 15 minutes followed by rest (W15R), and walking for 30 minutes followed by rest (W30R), random order was determined by a Latin Square. Thermocouples were inserted into both TS 1.5 cm + ½ skinfold measure. Participants rested quietly until the intramuscular temperature stabilized (±0.1 °C) for five minutes, at this time baseline temperature was recorded. During all conditions, a 1-kg ice bag was applied with flexi-wrap directly over the insertion site on the participant's TS and time started. Participants either rested supine or immediately started walking on a treadmill at 4.5 km/h for the appropriate time according to condition. After walking, the participants rested until the TS decreased by 6°C from baseline . A 1x3 within groups ANOVA was used to determine the effect of activity level on time for TS temperature to decrease 6°C from baseline. **Main Outcome Measures:** Time needed (including walking time) for the TS intramuscular temperature to decrease 6ºC below baseline. A secondary outcome was the time needed for cooling after the subjects stopped walking. **Results:** Rest condition cooled faster (25.9±5.5 min) than both W15R (33.7±9.3 min) ($P=0.002$) and W30R (49.4±8.4 min) ($P<0.001$). Additionally, W15R cooled faster than W30R ($P=0.004$). After walking stopped, it took 18.7±9.3 min and 19.4±8.4 min for the TS temperature to decrease 6ºC during the W15R and W30R conditions respectively. **Conclusions:** Optimal cooling time occurs at rest. If a patient must walk to another commitment, clinicians need to have the patient walk for the shortest amount of time possible and continue to ice for 20 minutes after they stop walking.

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**Effect Of Slush Bucket Ice To Water Ratio During 10- And 20-Minute Immersions On Triceps Surae Interface And Intramuscular Tissue Temperatures**


Nelson CJ, Brucker JB, Shappy J: University of Northern Iowa, Cedar Falls, IA


**Context:** The latent heat of fusion of ice makes it very effective at removing heat. Thus, cooling efficacy could be enhanced by having a greater ice to water ratio during immersion treatments. Moreover, a shorter treatment duration could be possible with a greater ice to water ratio. **Objective:** Compare interface and *in vivo* muscle temperatures during cold immersions using 2 different ice to water ratios and treatment durations. **Design:** Crossover trial. **Setting:** Laboratory. **Patients or Other Participants:** Sixteen active volunteers (M: 8, F: 8, age= 21 ± 2yrs, ht= 173.0 ± 12.1cm, mass= 75.0 ± 12.4kg, skinfold= 21.7 ± 4.0mm, & girth= 37.2 ± 3.0cm) in accordance with university IRB. **Interventions:** During 2 sessions separated by at least 48 hours both legs were immersed independently in 38 liter tall cylinder coolers filled to the 34 liter mark. Independent variables were ice to water Ratio (8:1 & 1:1), treatment duration [(TxDur) 10-min & 20-min], and time [Baseline and End of Treatment (EoTx)]. **Main Outcome**

**Measures:** Triceps Surae interface (IF) and intramuscular [(IM) 1 cm + ½ skinfold thickness] temperatures to the nearest 0.1°C. Repeated measures ANOVAs at *a priori* of .05 were performed on IF & IM temperatures, separately. Tukey-Kramer MC tests were used when necessary. **Results:** The only effect Ratio had was indicated when it interacted with Time ($F_{1,15}$ = 5.60, *P* = .03) on IF. At Baseline the 1:1 (31.3 ± 0.9°C) and 8:1 (31.2 ± 0.8°C) IF were similar (*P*= .46), but at EoTx the 1:1 (3.4 ± 1.7°C) was 0.6°C warmer (*P*= .03) than the 8:1 (2.8 ± 0.9°C)(MSE=1.0) with both the 1:1 and 8:1 cooling over time (P< .001). As expected both IF and IM were affected by the interaction of TxDur and Time (*P* < .004 & *P* < .001, respectively). Specifically, IF during the 10-min decreased (*P*< .001) from 31.1 ± 0.3°C to 3.6 ± 1.4°C (MSE= 1.4); whereas, during the 20-min IF decreased (*P*< .001) from 31.3 ± 0.9°C to 2.6 ± 1.2°C (MSE= 1.4). Eventhough at Baseline both TxDur temperatures were close (*P*= .24), the 1.0°C warmer (*P*= .02) 10-min over the 20-min at EoTx could be important (MSE= 2.2). Likewise, IM during the 10-min decreased (*P*< .001) from 34.8 ± 0.7°C to 31.6 ± 2.0°C (MSE= 4.4); whereas, during the 20-min IM temperatures decreased (*P*< .001) from 35.0 ± 0.6°C to 26.8 ± 2.8°C (MSE= 6.1). At Baseline, both TxDur were similar (*P*= .17), but at EoTx the 20-min was 4.8°C cooler (*P*<.001) than the 10-min (MSE= 1.6). **Conclusion:** Slush buckets with higher than a ½ ice to water ratio for leg immersion treatments less than 20 minutes is not necessary.

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### Cold Water Immersion Has No Effect On Maximal Performance In Collegiate Soccer Players

Rupp KA, Selkow NM, Parente WR, Weltman AL, Ingersoll CD, Saliba SA: University of Virginia, Charlottesville, VA

**Context:** During peak competitive periods, elite athletes are often required to perform at levels of high intensity over multiple days with limited rest. Recovery times of less than 48-hours between competitions may lead to decreased subsequent performance in these athletes. Cold water immersion (CWI) has been shown to maintain sprint performance and squat jump over time in cyclists, but there is limited evidence to support this recovery strategy in other athletic populations. **Objective:** To examine the performance effects of CWI as a recovery modality after volitional, exhaustive exercise in collegiate soccer players. **Design**: Single-blind, randomized controlled laboratory trial. **Setting**: Athletic Training Facility. **Patients or Other Participants:** Twenty-two (13M, 9F) division one collegiate soccer players (age 19.8±1.1 years, height 174.0±9.0 cm, mass 72.1±9.1 kg) with no history of injury to the lower extremity in the previous 6 weeks and no current open skin wounds on the torso or lower extremity were included. **Interventions:** The Yo-Yo Intermittent Recovery Test (YIRT) was used to simulate exhaustion from competition. Subjects progressively increased sprint speed between markers set 20 m apart until pace was failed. Subjects in the CWI group were immersed to the umbilicus for 15 minutes in a 12°C pool while the control group sat quietly for 15 minutes. **Main Outcome Measures**: Along with final stage reached in YIRT, a countermovement vertical jump test (CMVJ) was used to assess anaerobic power, and a 10 cm horizontal visual analog scale with no markings other than left and right anchors was used to assess perceived fatigue in the legs (PF). All participants were familiarized with testing procedures prior to participation. Participants received the recovery intervention (CWI or control) within 30 minutes of completing testing. Final stage of YIRT was measured at 0- and 48-hours, CMVJ was measured prior to, immediately, 24- and 48-hours post-YIRT, and PF was measured immediately, 24- and 48-hour post-YIRT. An analysis of variance with repeated measures was used to determine changes in performance on the YIRT and CMVJ, as well as self-reported PF over 48 hours. **Results**: There were no significant differences between intervention groups on YIRT performance (control 19.9±3.5 stage, CWI 20.9±3.5 stage, p =0.647) or PF (control 9.4±0.5 cm, CWI 9.3±0.6 cm, p=0.648) at 48-hours. There was a main time effect for CMVJ over 48-hours, but there were no group differences (pre-YIRT 64.6±11.0 cm, post-YIRT 66.4±10.9 cm, 24h-post 63.4±9.9 cm, 48h-post 63.1±9.4 cm, p=0.02). **Conclusions:** In collegiate soccer players, CWI does not affect subsequent performance when simulated events are separated by 48 hours. Highly trained athletes were able to maintain their performance on a maximally exhaustive exercise test regardless of intervention. Forty-eight hours between exhaustive exercise may be a sufficient recovery time in collegiate soccer players.

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### The Effects Of Adipose Thickness On Temperature Change In Human Muscle

Rubley MD, Liceralde PE, Tritsch AJ, Tandy RD, Holcomb WR, Milligan MD: Athletic Training Research Laboratory, University of Nevada Las Vegas, Las Vegas, NV

**Context:** The effectiveness of cryotherapy to reduce muscle temperature is influenced by adipose thickness, but it is unclear if the thermodynamic properties of adipose and muscle tissue differ enough to alter treatment outcomes. **Objective:** To determine whether the thermodynamic properties of adipose differs from muscle tissue, and results in altered muscle temperature changes during cryotherapy when measuring temperature change at a fixed depth of 3 cm or a variable depth of 2 cm plus the adipose. **Setting:** Controlled, laboratory setting. **Patients or Other Participants:** Nineteen healthy subjects (7 Men, 12 Women, age = 24.2 ± 3.0 years, height = 169.0 ± 5.8 cm, mass = 76.94 ± 11.5 kg, skinfold thickness = 13.9 ± 4.1 mm) with no contraindications for cryo-therapy. **Interventions:** Thirty-minute cryotherapy treatment (crushed ice bag with an elastic wrap) was applied bilaterally to all subjects, who were separated into 2 groups by skin fold thickness (less than 15 mm or 15mm and greater) on the posterior aspect of the right and left gastrocnemius. Intramuscular tissue temperature was assessed with an Isothermex (Columbus Instruments, Columbus, OH) via IT-21 Single Sensor Probes (Physitemp, Clifton, NJ) at 2 depths (30 mm in right leg or 20 mm plus ½ the skinfold thickness in the left leg). Thus there were four distinct conditions (1. <15mm adipose 30mm depth, 2. <15mm adipose variable depth, 3. >15mm adipose 30mm depth, and 4. >15mm adipose variable depth. For these 4 conditions the change in temperature from time 0 min to 30 min was analyzed with a one-way ANOVA, and Tukey's HSD tests. **Main Outcome Measures:** Change in intramuscular tissue temperature. **Results:** The main effect for change in temperature was significant ($F_{3, 34}$ = 4.88, p = .009). Post Hoc analysis of mean temperature differences among the four conditions revealed a significantly larger decrease in temperature for condition 1, 9.51±3.70° (p =.007), and condition 2, 8.75±1.93° (p =.039) when compared to condition 4, 5.55±1.63° after a 30 min cryotherapy application. The change in muscle temperature for condition 3 was 7.98±1.91°, which was not different from conditions 1, 2 or 4. **Conclusions:** Adipose thickness did not influence the magnitude of temperature decline, because there were no

differences between conditions 1 and 3. This suggests the thermodynamic properties of adipose and muscle may not differ. Because conditions 1 and 2 (30.0 mm and 30.4mm depth) were different than condition 4 (37mm mean depth), depth of temperature measurement influenced change in tissue temperature. The clinical application is that longer treatment durations are required for treatments at greater depths.

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**Pulsed Short-Wave Diathermy Does Not Influence Soleus Motor Function**

Varilek BP, Girod LM, Moles KD, Long BC, Draper DO: Department of Health and Human Performance, Oklahoma State University, Stillwater, OK, and Human Performance Research Center, Brigham Young University, Provo, UT

**Context:** Clinically it is suggested that heat causes a decrease in motoneuron pool recruitment. **Objective:** Determine if pulsed short-wave diathermy (PSWD) influences involuntary motoneuron pool recruitment and voluntary plantarflexion peak torque of the soleus muscle immediately following or 30-minutes following a standard 20-minute treatment. **Design:** A randomized controlled laboratory study. **Setting:** Controlled laboratory setting. **Patients or Other Participants:** Forty-five healthy subjects (male: n=22, age=22.45±2.58yrs, ht=179.76 ±4.89cm, mass=83.43±13.47kg; female: n=23, age=20.43±1.24yrs, ht=164.77±7.03cm, mass=65.85±14.71kg) with no history of lower extremity surgery or injury in the 12 months prior to the study volunteered. **Interventions:** Subjects were positioned supine where a series of stimuli were administered to the tibial nerve to attain a $H_{max}$ and $M_{max}$ measure. Immediately following each measure, subjects were positioned on an isokinetic dynamometer where plantarflexion peak torque measures were performed. Following the dynamometer measures, subjects returned to the table where a 20-minute PSWD, placebo, or no PSWD was administered to the anterio-lateral ankle joint. **Main Outcome Measures:** The dependent variables of this study included: $H:M_{max}$ ratio, peak plantarflexion torque, and skin surface temperature (°C). Differences in $H:M_{max}$ ratios, peak plantarflexion torque, and surface temperature between treatments were determined with three 3 X 3 ANOVAs with repeated measures on time. Tukey-Kramer post-hoc multiple comparison tests and two-factor interactions were used to examine differences between treatment and time for each dependent variable measured. Confidence intervals (95 %) were calculated for the $H:M_{max}$ ratios, peak plantarflexion torque, and surface temperature. Results were considered statistically significant at an alpha level of $P<.05$. **Results:** Pulsed short-wave diathermy did not influence the $H:M_{max}$ ratio ($F_{2,42} = 0.23$, $P = .79$) and plantarflexion peak torque ($F_{2,42} = 0.47$, $P = .63$). There was also no difference between the 3 measurement times for $H:M_{max}$ ratio ($F_{2,84} = 0.23$, $P = .79$) and peak plantarflexion torque ($F_{2,84} = 0.47$, $P = .63$). Pulsed short-wave diathermy increased surface temperature immediately following the treatment ($P<.05$). Ambient air temperature fluctuated less than 1° C during the data collection. **Conclusions:** Pulsed short-wave diathermy did not influence involuntary motoneuron pool recruitment or voluntary plantarflexion peak torque of the soleus muscle immediately following or 30-minutes following a standard 20-minute treatment.

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**The Effects Of Ultrasound Transducer Velocity On Intramuscular Tissue Temperature Across A Treatment Site**

Liceralde P, Holcomb WR, Rubley MD, Tandy RD, Schuerman S: University of Nevada, Las Vegas, Las Vegas, NV

**Context:** Thermal ultrasound is a commonly used and misused therapeutic modality. Due to a non-uniform beam, the ultrasound transducer must be continuously moved during treatments. The recommended velocity is 4 cm/s but this recommendation has not been adequately tested. The recommended treatment area is two times the size of the transducer head but whether uniform heating occurs throughout the treatment area remains unclear. **Objective:** To determine whether transducer head velocity has an effect on change in intramuscular tissue temperature, and to determine if uniform heating occurs within the treatment area. **Setting:** Controlled, laboratory setting. **Participants:** Twelve healthy subjects (age=24.3±2.9 years, height=171.3±7.4 cm, mass=81.5±19.3 kg, skinfold thickness=25.1±2.6 mm) with no contraindications for thermal ultrasound. **Interventions:** Independent variables were transducer velocity (2 cm/s, 4 cm/s, and 6 cm/s) and location of thermocouple within the treatment area (center, periphery of effective radiating area (ERA), and periphery of treatment site). Changes in dependent variable, intramuscular tissue temperature, were assessed with an Isothermex (Columbus Instruments, Columbus, OH) via IT-21 Single Sensor Probes (Physitemp, Clifton, NJ) at a depth of 2.5 cm below the skin surface. A 10-minute ultrasound treatment with 1 MHz frequency and 1.5 W/cm$^2$ intensity was administered with an Omnisound 3000 (Accelerated Care Plus, Sparks, NV). The crystal was 5 cm$^2$ with an ERA of 4.9 ± .2 cm$^2$ and a BNR of 3.5:1. Data were analyzed with a repeated measures factorial ANOVA. Pairwise comparisons using Bonferroni post hoc tests were used in the case of significant main effects. **Main Outcome Measures:** Intramuscular tissue temperature at each location during three velocities. **Results:** Statistical analysis revealed a significant main effect for treatment site location ($F_{2, 22} = 112.01$, and $p < .001$). The main effect for velocity was not significant ($F_{2, 22} = .061$, $p = .941$) and the velocity by location interaction was not significant ($F_{3.2, 35.3} = .313$, $p = .828$). Post hoc analysis revealed a significant difference in change in intramuscular tissue temperature between ERA and center ($p < .001$), ERA and periphery of the treatment area ($p < .001$), and the center and periphery of the treatment area ($p < .001$). When collapsed across velocity, mean ± SD temperature increases were 4.38 ± .08, 1.89 ± .17, and 0.72 ± .03°C for the center, periphery of the ERA and periphery of treatment site, respectively. **Conclusions:** Among the velocities tested, sound head velocity has no effect on temperature rise when applying ultrasound. The significant differences in temperature change across the treatment area indicate that uniform heating does not occur within the treatment area. Clinicians should be aware that when recommended treatment parameters are used, the anticipated temperature increases will only occur toward the center of the treatment area.

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**A Comparison Of Intramuscular Temperature Changes With Pulsed Short-Wave Diathermy And Autosound™**

Wheeler AA, Long BC. School of Human Performance and Recreation, The University of Southern Mississippi, Hattiesburg, MS, and Department of Health and Human Performance, Oklahoma State University, Stillwater, OK

**Context:** The Autosound™ therapeutic ultrasound device is currently used by clinicians. The benefit of using this device is that it remains stationary and does not require a clinician to constantly administer the treatment. Pulsed short-wave diathermy (PSWD) is another stationary device used by clinicians. It is suggested that PSWD may be more beneficial at increasing intramuscular temperature because the treatment size is greater than the Autosound™. No investigators however have examined intramuscular temperature changes using the Autosound™. **Objective:** Determine if an Autosound™ treatment with different amounts of transmission gel on each side of the gel pad is as effective as PSWD at increasing

intramuscular temperature. **Design:** A 3 X 3 factorial with repeated measures. **Setting:** Laboratory. **Patients or Other Participants:** Twenty-seven healthy volunteers (male: n=12, age=21.25±1.22 yrs, ht=165.54±7.77 cm, mass=63.56±6.41 kg, skinfold =22.62±5.72 mm; female: n=15, age=23.73±3.20 yrs, ht=178.37±5.42 cm, mass=88.42±18.82 kg, skinfold=15.81±4.89 mm) with no history of lower extremity injury or surgery involving a metal implant in the tested leg were recruited. **Interventions:** We examined 3 treatments (20-minute, continuous, 1.0MHz, 2.0W/cm$^2$ Autosound™ with 5 cc of gel on one side of the gel pad, 20-minute, continuous, 1.0MHz, 2.0W/cm$^2$ Autosound™ with 2.5 cc of gel on each side of a gel pad, and 20-minute PSWD) at 3 times (pretreatment, immediate posttreatment, and 10-minutes posttreatment). Subjects were positioned on their stomach. A 3x3 in area on the medial side of the left calf muscle was shaved and cleansed prior to implanting temperature probes. The implantable probes were inserted perpendicular to the calf to a depth of 3 cm. Baseline temperature measures were taken for 5 minutes prior to applying 1 of the 3 treatments. Following each treatment, subjects remained on the table for an additional 10 minutes for posttreatment temperature measures. **Main Outcome Measures:** Change in intramuscular temperature at the 3 cm depth and ambient air temperature. **Results:** There was a significant (treatment x time) interaction for intramuscular temperature ($F_{4,48}$=7.51; *P*=.0001). Autosound™ increased intramuscular temperature immediately following (*P*<.05) but not 10 minutes following the treatment (*P*>.05). Pulsed short wave diathermy increased intramuscular temperature more than the Autosound™ with 5 cc of gel or Autosound™ with 2.5 cc of gel on each side of a pad (*P*<.05; 38.07±1.02°C, 36.78±0.41°C, and 36.94±1.27°C, respectfully). There was no difference between the Autosound™ with 5 cc of gel or Autosound™ with 2.5 cc of gel immediately following or 10 minutes following the treatment (*P*>.05). Ambient temperature fluctuated less than 1°C during data collection. **Conclusions:** Under these set parameters the Autosound™ is effective at increasing intramuscular temperature. These temperature increases however, were not as significant as PSWD. The amount of transmission gel on the Autosound™ gel pad did not influence temperature changes.

# Free Communications, Oral Presentations: Factors Modifying Lower Extremity Biomechanics

Friday, June 25, 2010, 1:00PM-2:15PM, Room 201C; Moderator: Pat McKeon, PhD, ATC

### The Influence Of Ankle Dorsiflexion Range Of Motion On Landing Biomechanics

Fong C, Blackburn JT, Norcross MF, McGrath M, Padua DA: University of North Carolina at Chapel Hill, Chapel Hill, NC; Boston University, Boston MA; University of North Carolina at Chapel Hill, Chapel Hill, NC; University of Nebraska – Omaha, Omaha NE

**Context:** Sagittal plane joint displacements are essential for force attenuation during landing tasks. Lesser ankle dorsiflexion displacement is associated with lesser knee flexion displacement and greater ground reaction forces during jump landings. Additionally, restricted dorsiflexion range of motion (ROM) is associated with greater knee valgus displacement during controlled squatting tasks. As lesser knee flexion displacement, and greater knee valgus displacement and ground reaction forces during landing increase ACL loading, dorsiflexion ROM restrictions may potentially increase ACL injury risk. However, it is currently unclear if ankle dorsiflexion ROM influences landing biomechanics. **Objective:** To evaluate relationships between passive ankle dorsiflexion ROM and landing biomechanics. **Design:** Correlational. **Setting:** Research laboratory. **Patients or Other Participants:** Thirty-five healthy, physically active volunteers (17 Males, 18 Females, Age: 20.54 ± 1.50 years, Height: 1.77 ± 0.10 m, Mass: 73.42 ± 14.11 kg). **Interventions:** Lower extremity biomechanics of the dominant leg were assessed via an optical motion capture system interfaced with a force plate as subjects completed 5 jump landings from a 30 cm high box positioned 40% of their height behind the force plate. **Main Outcome Measures:** Peak passive ankle dorsiflexion ROM was measured in 0° (extended-knee) and 90° (flexed-knee) of knee flexion using a standard goniometer. Knee flexion and knee valgus angular joint displacements were calculated as the difference between the joint angle at initial ground contact (IGC) and the peak joint angle during the loading phase (i.e. IGC to peak knee flexion). Peak vertical (vGRF) and posterior (pGRF) ground reaction forces were also identified during the loading phase and normalized to body mass. The relationships between mean values for the biomechanical measures and mean ROM measures in each condition were assessed via bivariate Pearson correlation coefficients ($\alpha \leq 0.05$). **Results:** Significant correlations were noted between extended-knee dorsiflexion ROM and knee flexion displacement (r = 0.464, $p$ = 0.029), vGRF (r = -0.411, $p$ = 0.014), and pGRF (r = -0.412, $p$ = 0.014). The relationship between knee valgus displacement and extended-knee dorsiflexion ROM was non-significant (r = -0.290, $p$ = 0.091). Similarly, the relationships between flexed-knee dorsiflexion ROM and knee flexion displacement (r = 0.327, $p$ = 0.055), knee valgus displacement (r = -0.330, $p$ = 0.053), vGRF (r = -0.311, $p$ = 0.097), and pGRF(r = -0.295, $p$ = 0.085) were all non-significant. **Conclusions:** Greater extended-knee dorsiflexion ROM is associated with greater knee flexion displacement and lesser ground reaction forces during landing. These factors purportedly constitute a biomechanical profile associated with reduced ACL loading and injury risk. As a result, the current findings suggest that clinical techniques to increase plantarflexor extensibility and dorsiflexion ROM may be important components of ACL injury prevention programs.

### Effects Of An Orthosis And An Augmented Low-Dye Taping On Plantar Pressures And Pain In Subjects With Plantar Fasciitis

Andrus TL, Van Lunen BL, Walker ML, Cortes N, Oñate JA: Old Dominion University, Norfolk, VA

**Context:** Research has demonstrated that both arch taping and orthoses can cause an immediate decrease in plantar pressure and pain in subjects with plantar fasciitis. It is not clear, however, whether one of these treatments is superior to the other for active adults with this pathology. **Objective:** To compare the effects of the augmented low-dye taping (ALD) and a heel-pain orthosis (HPO) on pain, peak plantar pressure (PPP) and mean plantar pressure (MPP) under multiple areas of the foot in subjects with plantar fasciitis while walking and jogging. **Design:** Crossover study design. **Setting:** Controlled Laboratory. **Participants:** Seventeen subjects, 5 males (34.8±15.3 years of age, 1.82±0.2 m, 93.9±22.7 kg) and 12 females (36.8±16.5 years of age, 1.67±0.1 m, 70.8±12.5 kg) with plantar fasciitis participated in this study. Subjects had no history of lower

extremity surgery and no history of back or lower extremity injury in the last three months other than the condition sought. **Interventions:** Subjects were evaluated in a single session during baseline (no intervention) and two interventions (ALD, HPO) under conditions of walking and jogging. **Data Collection/ Main Outcome Measures:** During baseline and each intervention, subjects walked (0.89-1.34m/s) 3-minutes and jogged (2.24-3.13m/s) 3-minutes on a treadmill. Pain was assessed 2 times under each condition using the Visual Analog Scale(VAS). Peak and mean plantar pressures were assessed under the lateral rearfoot (LR), medial rearfoot (MR), lateral forefoot (LF), and medial forefoot (MF). Walking and jogging pressure measurements were recorded 3 times for 30 seconds using the PEDAR in-shoe pressure measuring system (Novel Electronics Inc, St. Paul MN USA). **Data Analysis:** Separate 3 (intervention) x 4 (mask) repeated measures analysis of variance (ANOVA) for each dependent variable under each task were conducted to evaluate the hypotheses. Separate repeated measures ANOVAs were also conducted for mean pain levels for each intervention and condition. Alpha level was set *a priori* at 0.05. **Results:** The ALD produced a significant decrease in walking MPP (44.66±14.46) under the LR when compared to the control (57.92±22.18, $p$=0.024). The ALD also significantly decreased jogging MPP (55.05±18.27) compared to the control (67.22±20.95, $p$=0.002) and the HPO (68.51±17.57, $p$=0.002). During walking, the HPO (7.12±10.08, $p$<0.002) and ALD (6.24±5.71, $p$<0.006) produced a significant decrease in VAS scores compared to the control (17.32±17.86). Jogging VAS scores also significantly decreased after the application of the HPO (12.15±15.61, $p$<0.003) and ALD (10.09±8.87, $p$<0.001) compared to the control (26.65±22.38). There were no significant differences in VAS between the HPO and ALD during walking and jogging. **Conclusions:** Both the HPO and ALD produced statistically and clinically significant decreases in subjects VAS scores while walking and jogging. ALD was better at decreasing plantar pressure in jogging and may be a better choice of treatment for active adults.

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**The Effects Of Ankle Bracing On Sagittal And Frontal Plane Landing Kinematics At The Knee And Ankle**

Zinder SM, Fong C, Blackburn JT, Norcross MF, Enrique D, Padua DA: University of North Carolina at Chapel Hill, Chapel Hill, NC

**Context:** For decades, clinicians have utilized external stabilization in an attempt to decrease the incidence and severity of ankle injuries. While the specific mechanism of this decrease is unknown, there exists epidemiologic evidence of the efficacy of ankle braces in reducing ankle injury rates. The effect this ankle bracing has on the kinematics of the entire lower extremity, however, is less understood. **Objective:** To assess the effect of ankle bracing on lower extremity kinematics in the sagittal and frontal planes following a jump landing. **Design:** A repeated measures pre-post test design. **Setting:** Controlled, laboratory setting. **Patients or Other Participants:** Twenty-six healthy, physically active volunteers (12 males, 14 females, age = 20.36 ± 1.47 years, height = 173.04 ± 13.61 centimeters, mass = 74.79 ± 15.15 kilograms) with no current lower extremity injury. **Interventions:** Lower extremity biomechanics of the dominant leg were assessed with a digital optical motion capture system interfaced with a force platform. Subjects completed five jump landings from a 30 cm high box positioned 40% of their height from the force plate with and without a lace-up ankle brace fitted to their dominant ankle. **Main Outcome Measures:** Sagittal and frontal plane kinematic measurements were recorded at two time points: initial contact with the force platform and over the loading phase, defined as initial contact to the point of maximum knee flexion. Dependent variables were knee flexion angle, ankle flexion angle, knee valgus angle, and ankle inversion angle at initial contact and the peak values over the loading phase. Data were analyzed with eight separate dependent t-tests. **Results:** The application of an ankle brace led to significantly increased knee flexion (no brace = 13.56°±5.58; brace = 15.68°±5.14; $P$<.001), decreased ankle plantar flexion (no brace = 51.28°±13.65; brace = 45.05°±10.70; $P$<.001), increased knee valgus (no brace = -1.29° ±2.62; brace = -2.19°±2.50; $P$<.001), and increased ankle inversion (no brace = 9.42°±6.89; brace = 11.18°±6.44; $P$=.018) at initial contact. During the loading phase, application of the brace led to increased plantar flexion (no brace = 8.09°±6.18; brace = 10.47°±5.28; $P$=.001), increased knee valgus (no brace = -6.02°±7.25; brace = -7.37°±6.83; $P$<.001), and increased ankle inversion (no brace = 8.30°± 6.64; brace = 10.78°±6.36; $P$=.001). **Conclusions:** Our findings revealed that the application of an ankle brace changed the sagittal and frontal plane landing kinematics in both the ankle and knee. In using external stabilization, as clinicians we need to be wary of the effects of changing the kinematic characteristics of one joint on the other joints in the system. Further work is needed to determine the consequences of these kinematic changes.

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**The Effect Of Low-Mobile Foot Posture On Walking Gait Kinetics**

Fruin AA, Cobb SC: Georgia State University, Atlanta, GA, and Department of Human Movement Sciences, University of Wisconsin-Milwaukee, Milwaukee, WI

**Context:** As physical activity is becoming more prevalent in today's society, so too are the number of reported lower extremity injuries. Although substantial research investigating the etiology of injuries with respect to foot posture has been performed, study results have been inconsistent. Poor intra-/inter- tester reliability associated with traditional foot posture assessment techniques may be a contributing factor to the inconsistent results. **Objective:** To compare walking gait kinetics between participants with typical (TYP) and low-mobile (low arch, hypermobile) (LMF) foot postures quantified using a measurement method with moderate-high intra- and inter-tester reliability. **Design:** Two group comparative study. **Setting:** Controlled laboratory setting. **Participants:** Twenty-two participants with no history of lower extremity surgery and free from lower extremity injury within the previous six months were classified into LMF (m=6, f=5, age=26.0 ±7.5 years, mass=77.2 ±13.8 kg, height =173.9 ±10.3 cm) and TYP (m=8, f=3, age=25.2 ±3.2 years, mass=84.9 ±22.0 kg, height=176.8 ±12.0 cm) foot posture groups. **Methods:** A digital caliper was used to quantify arch height and foot mobility using the arch ratio (AR) in 90% weight bearing and the relative arch deformity (RAD) ratio, respectively. An AMTI force platform (Advanced Mechanical Technology, Newton, MA) mounted within a 10 m walkway and sampling at 960 Hz was used to measure ground reaction force (GRF) data as participants completed five walking trials (1.3-1.4 m/s) wearing the same style sandal. A custom software program was then used to normalize GRF data to body weight and ensemble average each participant's five gait trials. Three-dimensional peak forces during stance and peak instantaneous loading rate during four stance subphases [loading

response (0-16%), midstance (16-48%), terminal stance (TS) (48-81%), preswing (PS) (81-100%)] were then computed. **Main Outcome Measures:** Independent variables were the foot posture groups and dependent variables were the peak forces during stance and instantaneous peak loading rate during the stance subphases. One-way ANOVAs ($\alpha<0.05$) were performed to investigate between group gait kinetic differences. **Results:** Anterior peak force (TYP: 0.26 ±0.03 N/BW; LMF: 0.23 ±0.03 N/BW; p=0.028) was significantly lower in the LMF group. There were no significant peak instantaneous loading rate differences between the TYP and LMF groups during any of the stance subphases. **Conclusions:** Our results suggest walking gait kinetics are significantly affected by low-mobile foot posture quantified using a measurement method with moderate-high intra-/inter- tester reliability. During walking gait, anterior peak force occurs during late stance, when the foot must be rigid to support propulsion. The significantly decreased peak observed in the LMF group may be related to decreased osseous stability and increased dependence on dynamic stabilizers associated with a low-mobile foot posture. If so, low-mobile foot posture may be associated with increased risk of repetitive stress related lower extremity injury.

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**Influence Of Femoral Anteversion And Pelvic Angle On Hip And Knee Motions During A Single Leg Hop**

Nguyen A, Cone JR, Shultz SJ: College of Charleston, Charleston, SC, and University of North Carolina at Greensboro, Greensboro, NC

**Context:** Reasons to explain why functional valgus collapse is more prevalent in females is currently unknown. Sex differences in static alignment of the hip and pelvis have been suggested to contribute to greater joint motion in females as they are known to have greater anterior pelvic angle (PA) and femoral anteversion (FA) compared to males. However, it is unknown whether these proximal alignment factors contribute to increased joint motion during landing tasks in females. **Objective:** To determine if PA and FA are associated with hip and knee motions during a single leg hop (SLH) task. **Design:** Descriptive cohort. **Setting:** Controlled, laboratory. **Patients or Other Participants:** Thirty five recreationally active females (22.5±3.1yrs, 162.4±7.2cm, 61.9±9.2kg) with no current lower extremity injury, or any previous history that would detract from the ability to perform a SLH. **Interventions:** PA, FA and three-dimensional kinematics of the hip and knee during SLH trials were assessed on the dominant stance leg. PA was measured in standing using an inclinometer while FA was measured prone using the Craig's test. SLH trials began while standing on the stance leg and taking a hop forward, landing on the same leg (hop distance=40% of height, minimal vertical height=5"). The average of 3 measurements for each alignment characteristic and the average hip and knee excursions during the landing phase (initial contact to peak knee flexion) over 5 SLH trials were used for analyses. Step-wise linear regressions determined the extent to which PA and FA predicted each hip and knee excursion during the SLH. **Main Outcome Measures:** HA and PA were recorded to the nearest degree while joint excursion (degrees) was calculated (peak - initial joint angles) during the landing phase of the SLH [initial contact (GRF≥10N) to peak knee flexion]. **Results:** Means±SDs for PA and FA were 13.2°±4.0° and 13.9°±5.0°, respectively. Hip adduction, hip internal rotation, knee valgus and knee external rotation excursions were 11.7°±4.2°, 7.3°±4.6°, 1.7°±2.3°and 4.1°± 2.6°, respectively. Greater FA was a positive predictor of greater knee valgus ($R^2$=.199, *P*=.007) and greater knee external rotation ($R^2$=.145, *P*<.024) excursion. PA and FA were not significant predictors of hip adduction (*P*=.416) or hip internal rotation (*P*=.232) excursion. **Conclusions:** Structural alignment of the femoral neck was associated with increased motion at the knee given that greater FA was predictive of greater knee valgus and external rotation. Further work is needed to confirm if FA directly influences joint motion or if FA indirectly influences joint motion via changes in lower extremity neuromuscular function, resulting in less dynamic control of the lower extremity during landing tasks. ***Data were collected during a funded appointment supported by NIH-NIAMS Grant R01-AR53172.***

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**Quadriceps Muscle Activation And Radiographic Evaluation Following ACL Revision Surgery**


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**Context:** Complications requiring revised anterior cruciate ligament (ACL) reconstruction such as graft failure affect approximately 8-10% of the reconstructed population. Poorer outcomes including knee joint osteoarthritis are more likely. Quadriceps strength and activation may play an important role in the recovery from ACL revision surgery. **Objective:** Describe quadriceps strength and central activation ratio(CAR) and correlate with radiographic knee joint evaluation. **Design:** Case series. **Setting**: Laboratory. **Patients or Other Participants:** Twenty-one patients (8F,11M; 29.5 ±10.2years,172.5 ±7.5cm,80.7 ±19.2kg) who were on average 47.5 ±21.1 months [range:14-85months] post revision ACL reconstruction. **Intervention(s):** None. **Main Outcome Measures:** Patients performed maximal voluntary isometric contractions(MVIC) with the knee bent to 90-degrees bilaterally. As patients reached a force plateau, an electrical stimulus was manually triggered and delivered through 2 carbon-impregnated rubber electrodes secured to the anterior thigh(proximal-lateral and distal medial). The stimulus consisted of a train of 10, 0.6ms duration, 125V pulses delivered at a carrier frequency of 100Hz which caused a transient increase in knee extension torque above that of the MVIC (SIB torque). The central activation ratio(CAR) was calculated by dividing MVIC torque and SIB torque as an estimate of the proportion of the quadriceps motor neuron pool that can be activated during an isometric MVIC. CARs are presented as percents, MVIC values are presented as torques normalized to body weight. Radiographs (bilateral standing antero-posterior in knee flexion and lateral in full extension) were evaluated by a fellowship-trained orthopaedic surgeon using the International Knee Documentation Committee(IKDC) grading system. This system grades knee joint degeneration in each compartment (anterior, posterior, lateral, medial and patellofemoral) from 1(normal) to 4(severe). We used spearman rho correlation coefficients to calculate relationships between main outcome measures and IKDC score. the reconstructed limb and 85.5±9.5% on the contralateral limb. Average, normalized MVIC torque was 2.5±1.0Nm/kg on the reconstructed limb and 2.7±1.0Nm/kg for the contralateral limb. Only 9.5%(2/21) of patients had no radiographic evidence of knee joint degeneration; 57% had evidence of medial compartment degeneration, 66.7% lateral compartment, 52.4% patellofemoral compartment, 33.3% anterior compartment and 14.3% posterior compartment. Patient age at the time of follow-up evaluation was related to severity of knee joint degeneration, particularly the medial($\rho$=0.43,P=0.05), anterior ($\rho$= 0.47,P=0.03) and patellofemoral ($\rho$= 0.66,P=0.001) compartments. When separated by age into equal groups, the younger patients(n=10,age=20.6±1.8years) with lower CARs tended to have more severe degeneration in the patellofemoral joint ($\rho$=-0.73,P=0.02). Older patients (n=11,age= 37.6±8.8years) with lower normalized MVIC torque values tended to exhibit more severely graded degeneration in the patellofemoral joint ($\rho$=-0.65,P=0.03). **Conclusion:** Bilateral quadriceps central activation deficits and knee joint degeneration are evident in patients with history of ACL graft failure. The severity of patellofemoral joint degeneration is related to lower CARs in young patients but related to lower MVIC in older patients.

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**Incidence Of Premature Knee Osteoarthritis Following Anterior Cruciate Ligament Reconstruction Dependent On Autograft: Ipsilateral Bone-Patellar Tendon-Bone Vs Semitendinosus And Gracilis**


Vairo GL, McBrier NM, Miller SJ, Buckley WE: Athletic Training Research Laboratory, Department of Kinesiology, The Pennsylvania State University, University Park, PA


**Context:** Anterior cruciate ligament (ACL) reconstructions are post-operative conditions encountered by athletic trainers. Selection of autogenous graft options for surgical interventions is a controversial topic in orthopaedic sports medicine. Two established methods for reconstructing the ACL include harvest of ipsilateral bone-patellar tendon-bone (BPTB) and semitendinosus and gracilis (STG) autografts. However, a current outcome trend suggests the BPTB may accelerate progression of knee osteoarthritis. **Objective:** To systematically review literature investigating and comparing the incidence of post-operative knee osteoarthritis following ipsilateral BPTB and STG autograft ACL reconstruction in patients. When appropriate, meta-analyses were conducted. **Data Sources:** Survey of PubMed, The Cochrane Library, CINAHL PEDro and SPORTDiscus electronic databases was conducted using the keywords: anterior cruciate ligament, reconstruction, osteoarthritis, joint degeneration, patients. Literature searches were limited to human participants research studies published in English in peer-reviewed journals from 1998-2008. **Study Selection:** Over 100 titles were initially identified. Review of the abstracts yielded four articles (1 randomized control trial, 1 prospective non-randomized clinical trial, 1 prospective cohort and 1 retrospective cohort) appropriate for selection to detailed assessments. Research studies were excluded if they reported duplicate data or permitted concomitant surgical ligamentous repair and revisions for analysis. **Data Extraction:** Two investigators (GLV, NMM) compiled incidence rates for post-operative tibiofemoral and patellofemoral osteoarthritis detected via radiography. The research studies were also classified per the levels of evidence proposed by the Centre for Evidence-Based Medicine (Oxford, UK). Applicable articles (1 randomized control trial, 1 prospective non-randomized clinical trial) were further scrutinized with a validity score using the Physiotherapy Evidence Database (PEDro) scale by two investigators (GLV, NMM). **Data Synthesis:** Incidence rates for tibiofemoral and patellofemoral osteoarthritis were summed and converted to percentages. The absolute risk differences between BPTB and STG osteoarthritis rates were then calculated. When possible, the number needed to treat was also computed. Results demonstrated that 42/115 or approximately 37% of BPTB patients developed tibiofemoral osteoarthritis compared to 16/100 or 16% of STG patients. These data yield an absolute risk difference of 0.205 (95% CI = 0.087, 0.296) and a number needed to treat of 4.873 (95% CI = 3.187, 11.434). Furthermore, 12/29 or approximately 41% of BPTB patients developed patellofemoral osteoarthritis compared to 8/27 or approximately 30% of STG patients. These data display an absolute risk difference of 0.117 (95% CI = -0.129, 0.343) but additional data is necessary to compute the number needed to treat. The mean PEDro score was 4.5/10. **Conclusions:** Currently, level B evidence exists that an increased incidence of premature tibiofemoral osteoarthritis results from employing the BPTB ACL reconstruction technique as opposed to a STG method five-to-six years post-surgery in patients. Further investigation is warranted to confirm or refute the observed trend specific for incidence of patellofemoral osteoarthritis.

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**Absolute Baseline And Cyclic Variations In Knee Laxity Are Related To Anterior Tibial Translation When Transitioning From Non-Weight Bearing To Weight Bearing**

Shultz SJ, Schmitz RJ, Nguyen AD, Levine BJ, Montgomery MM, Shimokochi Y, Beynnon BD, Perrin DH: University of North Carolina at Greensboro, Greensboro, NC

**Context:** Anterior knee laxity (AKL) has received attention as an ACL injury risk factor. **Objective:** To examine the consequence of greater absolute baseline and cyclic increases in AKL on anterior tibial translation (ATT) during transition of the knee from non-weight bearing (NWB) to weight bearing (WB). **Design:** Females were prospectively measured on AKL for 6 days post menses onset and 8-10 days post ovulation over two cycles. Females and males were then measured on all relevant variables at two time points [when AKL was at minimum (T1) and maximum (T2) in females; males matched on time interval]. **Setting:** Controlled laboratory. **Participants:** Recreationally active females (normally menstruating) (N=71; 21.5±2.7yrs, 164.2± 6.7cm, 61.1±8.8kg), and males (N=48; 22.3± 2.7yrs, 177.9±9.3cm, 81.1±13.4kg). **Interventions:** AKL represented the anterior displacement of the tibia relative to the femur with a 133N anterior directed load (mm). Genu recurvatum (GR) was measured in supine as active knee hyperextension (°). ATT, knee flexion excursion (KFLEX=°) and surface electromyography were collected as the knee transitioned from NWB to WB (40% body weight load). Participants performed maximal effort isometric contractions (MVIC) at 20° knee flexion to obtain thigh muscle torques (Nm/Kg) and to normalize muscle responses (%MVIC) during measurement of ATT. **Main Outcome Measures:** ATT (mm) represented the anterior displacement of the tibia relative to the femur from just prior to initiation (NWB) to peak axial load. Linear regressions examined the relationships between absolute baseline (AKL_T1, GR_T1) and cyclic changes (AKLΔ, GRΔ)(females only) in knee laxity with ATT as measured at T1 and T2, and ATTΔ(T2-T1)(females only). These relationships were examined once controlling for KFLEX and thigh strength and activation. **Results:** AKL and GR increased in females (9.5% and 26.0%, respectively), but not in males, from T1 to T2 (P<.001). AKL and GR were significant predictors of ATT_T1 and ATT_T2, explaining 21.0% of the variance in males, and 12.5-13.1% of the variance in females (P<.05). While the associations (coefficients) between AKL_T1 and ATT were similar for males (.252 for ATT_T1, .358 for ATT_T2) and females (.234 for ATT_T1, .235 for ATT_T2), GR_T1 was a stronger predictor of ATT in males (.335 for ATT_T1, .297 for ATT_T2) than females (.048 for ATT_T1, .056 for ATT_T2). When predicting ATTΔin females, AKL and GR explained 10.4% of the variance (P=.04). Larger coefficients were noted for AKLΔwhen predicting ATT_T2 (0.864, P=.03) and ATTΔ(0.740, P=0.03) as compared to ATT_T1 (.333, P=0.37). **Conclusions:** When transitioning from NWB to WB, greater AKL (both absolute baseline and cyclic change) was associated with greater ATT. These findings provide insight into possible mechanisms for the association between greater knee laxity and ACL injury risk during the early weight acceptance of decelerating tasks. Funded by NIH-NIAMS #R01AR053172.

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**Representative Data For Functional Tasks On The Neurocom For Those With And Without Intra-Articular Knee Pathology**

Silkman C, Medina McKeon JM, Howard J, Mattacola CG, Lattermann C: University of Kentucky, Lexington, KY

**Context:** The step and over and lunge tasks are common lower extremity functional performance tests used on the NeuroCom to measure proprioception, force, and functional limitation. **Objective:** The objective of this study was to describe representative data from three subject populations for two functional tests performed per protocol on the Neurocom. **Design:** Descriptive, retrospective. **Patients or Other Participants:** 47 males and females were in the Control group (age=22.2±3.7yrs, mass=76.2±7kg, ht=173.0±2cm). The anterior cruciate ligament-reconstructed (ACL-R) group consisted of 18 males and females (age=22.6±5.8yrs, mass=77.7±5.8kg, ht= 176.3±10.1cm). The average time since reconstruction for the ACL-R group was 58±2 weeks. The autologous chondrocyte implantation (ACI) group consisted of 18 males and females (age=36.57±6.58 years, mass= 100± 62.5kg, ht= 174.42± 11.3 cm). Subjects in the ACI groups were presurgical. **Interventions:** Tasks were the Step-up-an-over (SUO) and Lunge performed per protocol on the NeuroCom. For all variables of interest, the involved limb (for ACL-R and ACI groups) or the dominant limb (for control group) was used. This limb would bare a majority of the weight during both task performances. Descriptive data for these two tasks are presented for each group (Control, ACL-R, ACI). **Main Outcome Measures:** Six dependent variables are presented (3 per task) for each group. The SUO variables are the Lift Index (LI), Movement Time (MT), and the Impact Index (II). The Lunge variables were Step Distance (DS), Impact Index (II), and Force Impulse (FI). Means, standard deviations, and 95% confidence intervals around the means are presented as descriptive data for each variable. **Results:** Values for the SUO_LI were Control = 56.8±12.7 (53.2, 60.4); ACL-R = 54.9 ±13.1 (48.9, 150.7); ACI = 38.8±10.9 (33.4, 44.1). For the SUO_MT, values were Control = 1.2±0.2 (1.1, 1.2); ACL-R = 1.3±0.2 (1.2, 3.6); ACI = 2.6±3.5 (0.8, 4.4). SUO_LI values were Control = 60.5±17.6 (55.5, 65.5); ACL-R = 61.1±19.7 (52.0, 70.2); ACI = 37.5±16.0 (30.1, 44.9). For the Lunge_DS values were Control = 50.2±6.01 (48.5, 51.9); ACL-R = 52.9±5.3 (50.4, 55.3); ACI = 2.7±9.4 (36.5, 48.8). For the Lunge_II, values were Control = 27.2± 7.3 (25.3, 29.3); ACL-R = 28.5± 9.9 (23.9, 33.1); ACI = 24.0± 5.7 (20.3, 27.7). For the Lunge_FI, values were Control = 91.7±15.3 (87.3, 96.1); ACL-R = 84.8±12.4 (79.0, 90.5); ACI = 140.3±37.2 (116.0, 164.6). **Conclusions:** Representative values for the specific variables in the Step-Up-and-Over and Lunge tasks using the NeuroCom in populations with and without intra-articular knee pathology were calculated. These data can be referred to for an accurate depiction of force, lunge distance, and lift index values for these three different populations.

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## EBF: Knee

Wednesday, June 23, 2010, 9:30AM-10:30AM, Room 202AB; Discussants: Joseph Hart, PhD, ATC, and Riann Palmieri-Smith, PhD, ATC; Moderator: Maureen Dwyer, PhD, ATC

## EBF: Head & Spine

Wednesday, June 23, 2010, 10:45AM-11:45AM, Room 202AB; Discussants: Erik Swartz, PhD, ATC, and Francis Feld, MEd, MS, CRNA, ATC, NREMT-P; Moderator: Ryan Tierney, PhD, ATC

## Free Communications, Oral Presentations: New Concepts in the Study of Sports-Related Concussion Dilemma

Wednesday June 23, 2010, 12:00PM-1:15PM, Room 202AB; Moderator: Tracy Covassin, PhD, ATC

**The Effects Of Cervical Muscle Strength And Player Anthropometrics On Biomechanical Measures Of Head Impact Severity In Youth Ice Hockey Players**

Mihalik JP, Guskiewicz KM, Blackburn JT, Cantu RC, Greenwald RM, Marshall SW: The University of North Carolina, Chapel Hill, NC; Emerson Hospital, Concord, MA; Simbex, Lebanon, NH; Thayer School of Engineering, Dartmouth College, Hanover, NH

**Context:** Strong anecdotal support for the role of the cervical musculature in mitigating the severity of head impacts exists. There is growing concern by advocates that permitting body checking in youth hockey may lead to increased injury rates due to large discrepancies in player size. **Objective:** To evaluate the effect of cervical muscle strength and player anthropometrics on biomechanical measures of head impact severity. We hypothesized stronger, heavier, and taller athletes would experience less severe head impacts. **Design:** Quasi-experimental prospective cohort. **Setting:** Field setting. **Patients or Other Participants:** Thirty-seven ice hockey players were recruited (age=15.0±1.0 years, height=173.5±6.2 cm, mass=66.6±9.0 kg, playing experience= 2.9±3.7 years). **Interventions:** Participants were equipped with accelerometer-instrumented helmets to collect biomechanical measures relating to head impacts (linear and rotational acceleration) over the course of an entire playing season. Prior to the season, cervical muscle strength was measured using isometric "break tests" for the following muscles groups: anterior neck flexors, anterolateral neck flexors, cervical rotators, posterolateral neck extensors, and upper trapezius. Two practice trials were permitted for each muscle group, and strength data from the ensuing three trials were recorded. The reliability of strength measures ranged from 0.82 to 0.97 ($ICC_{3,k}$). Player height and mass were recorded using a conventional medical scale. 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. **Main Outcome Measures:** Dependent variables included linear and rotational acceleration. Player height, mass, and cervical strength measures were separated into tertiles, thus categorizing each player for the general mixed linear model analyses into one of three groups: strongest (or heaviest/tallest), moderate, or weakest (or lightest/shortest). The individual trial strength measures were ensemble averaged and then normalized to body mass. **Results:** A significant difference in rotational acceleration ($F_{2,29}$=6.80; $P$=0.004) suggests the heaviest athletes in our sample (1675.8 rad/s$^2$; 95% CI: 1574.6-1783.4) experienced higher rotational accelerations than the lightest athletes (1467.3 rad/s$^2$; 95% CI: 1408.5-1528.5), but this finding was not observed for linear acceleration ($P$=0.692). No significant differences in acceleration ($P_{Lin}$; $P_{Rot}$) across tertile groups were observed for player height ($P_{Lin}$=0.665; $P_{Rot}$=0.716), anterior neck flexors ($P_{Lin}$=0.399; $P_{Rot}$=0.060), anterolateral neck flexors ($P_{Lin}$=0.987; $P_{Rot}$=0.579), cervical rotators ($P_{Lin}$=0.136; $P_{Rot}$=0.238), posterolateral neck extensors ($P_{Lin}$=0.883; $P_{Rot}$=0.101), and upper trapezius ($P_{Lin}$=0.892; $P_{Rot}$=0.689) were observed. **Conclusions:** Our hypotheses that stronger, heavier, and taller players would sustain less severe head impacts were not supported. Our strength findings are surprising, especially given the anecdotal support for cervical muscle strength as an important factor in mitigating head impact severity. It could be argued the role of cervical muscle strength is heightened only in anticipated collisions. While we evaluated cervical strength isometrically, dynamic methods should be explored in the context of head impact biomechanics.

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**Recovery From Sport-Related Concussion: A Preliminary Investigation Comparing Motor-Evoked Potentials, Post-Concussion Symptoms, And Neuropsychological Test Scores**

Livingston SC: University of Virginia, Charlottesville, VA, and University of Kentucky, College of Health Sciences, Department of Rehabilitation Sciences, Lexington, KY

**Context:** Mild traumatic brain injury (TBI) results in a complex cascade of ionic, metabolic and physiologic events which occur within minutes to hours after injury and may persist for a period of days to weeks. Patterns of impairment exhibited in concussed athletes provide indirect evidence of these phenomena through assessment of subjective complaints and cognitive functioning. Adding electrophysiologic testing to the acute assessment of concussion may provide more direct evidence for a similar course of neurophysiologic recovery. **Objective:** To compare motor evoked potentials (MEPs), self-reported symptoms and neuropsychological test scores following acute sport-related concussion and describe their respective recovery patterns. **Design:** Prospective, matched cohort, time-series design. **Setting:** Athletic training research laboratory. **Patients or Other Participants:** Nine Division I collegiate athletes (3 females, 6 males, age 20.0±0.87 years, height 177.4±7.6 cm, mass 78.5±6.5 kg). **Interventions:** Transcranial magnetic stimulation (TMS) was applied over the motor cortex and MEPs were recorded from the contralateral upper extremities. Post-concussion signs and symptoms (PCSS) were evaluated using the Head Injury Scale (HIS). The Concussion Resolution Index (CRI) neuropsychological

test battery was administered to assess athlete's cognitive functions. All measures were evaluated 1, 3, 5 and 10 days post-concussion. **Main Outcome Measures:** MEPs, HIS scores, CRI scores. Separate one-way repeated measures MANOVAs were used for comparison of PCSS, CRI scores, and MEP variables between days of testing. Paired samples *t* tests were used in the post-hoc analysis to determine differences between days of testing for each variable. **Results:** Scores on the HIS and CRI improved during the initial 1 to 10 days following concussion but MEPs did not. Concussed athletes reported more frequent and greater severity of symptoms on the first day following injury ($F_{3,24}$ = 18.2, *P*<.001) with a decline in symptoms over subsequent testing days. Scores on the HIS were significantly higher on test day 1 (somatic $F_{3,24}$ = 13.7, *P*<.001; neurobehavioral $F_{3,24}$ = 12.0, *P*=.002; cognitive $F_{3,24}$ = 9.4, *P*<.001) compared to day 10 . Processing speed on the CRI was slower on the first day post-concussion ($t_8$ = 4.6, *P*=.002) and demonstrated a steady improvement (faster PS) over the testing period. Median MEP latencies were significantly longer (slower) on testing day 10 (27.2±2.3 msec/m) compared to day 1 (25.4±1.4, $t_8$=-2.69, *P*=.03). Ulnar MEP amplitudes were significantly smaller on day 3 (.27±.10 μV) compared to day 5 (.41± 16, $t_8$ = -3.48, P=.008). **Conclusions:** In the initial 10 days following concussion, self-reported symptoms and neuropsychological test performance improved but MEP changes persisted. The pattern of impairments exhibited over the initial ten days post-concussion suggests different neuro-physiologic mechanisms responsible for producing MEP changes when compared with PCSS and neurocognitive deficits.

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**Exercise Capacity Is Limited In Participants With Post-Concussion Syndrome**

Kozlowski KF, DeVinney-Boymel LA, Leddy JL, Willer B: University of Buffalo, Buffalo, NY

**Context:** Exercise tests have been recommended as one tool useful in helping determine return to play for athletes with concussion or PCS yet studies on exercise test outcomes are limited in head injury. **Objective:** Compare the response to exercise in participants with and without PCS. **Design:** A cross-sectional study. **Setting:** This study was performed in a controlled laboratory setting. **Participants:** A convenience sample of 34 participants with confirmed diagnosis of PCS (age = 27.9 ±14.3 years, 17 males; average days post-injury = 226.24) were evaluated and compared to 10 participants from a laboratory historical control group (age = 26.5 ±8.2 years, 4 males) with no history of head injury. **Intervention:** Participants were evaluated for resting systolic and diastolic blood pressure (SBP & DBP), heart rate (HR). Symptoms were evaluated for presence during the previous 24 hours using the Graded Symptom Checklist (GSC) and the Head Injury Scale (HIS). An incremental treadmill test (GXT) was performed and terminated when subjects could no longer maintain intensity, or they felt as if there would have been a return of symptoms. Statistical analysis included independent t-tests for resting and maximal values of HR, BP and symptom reports and repeated measures ANOVA was used for stage recordings of HR, SBP and DBP. **Main Outcome Measures:** Values for HR, BP and Borg Rating of Perceived Exertion (RPE) were recorded regularly during the GXT and at test termination. Test duration was recorded in minutes. **Results:** The mean symptom scores were significantly greater in the PCS group in number of symptoms (9.94 ± 6.35 to 1.90 ± 2.13 GSC symptoms, p<0.001) and intensity of symptoms (20.85 ± 13.73 to 2.20 ± 4.02 HIS score, p<0.001). Resting HR was significantly higher in the PCS group (74.54 ±11.29 bpm to 67.24 ±6.58 bpm, p=0.031), while there were no significant differences in resting BP. The non-injured group demonstrated a greater tolerance for increased exercise workload compared to the PCS group based on their ability to achieve a significantly greater HR (175.90 ±15.30 to 142.76 ±24.05 bpm, p<0.001), greater test duration (16.30 ±4.22 to 8.50 ±4.36 min, p<0.001) and a greater RPE (17.30 ±2.11 to 13.03 ±2.71, p<0.001) at test termination. During the exercise test, there were no significant differences between groups at any given stage for HR or BP. After controlling for resting measures, HR differences at threshold remained significantly greater (p=0.001) in the non-injured group while BP values were not. **Conclusions:** Individuals with prolonged symptoms of concussion are limited in their ability to perform exercise. They experience the onset of new or worsening symptoms at a significantly lower workload than non-injured counterparts. An exercise challenge provides a measurable diagnostic tool for identifying limitations in patients with PCS. Funded by the NATA Foundation Doctoral Research Grant Program.

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**Model To Assess Factors Underlying Variable Response To Head Impact**

Mansell J, Tierney RT, Driban J, Higgins M, Clegg S, Mishra A, Krynetskiy E: Temple University, Philadelphia PA; Tufts Medical Center, Boston, MA; Lincoln University, PA; Towson University, Towson, MD

**Context:** It is unclear why individuals have variable responses to head impacts. This variability may be multi-factorial, with head impact acceleration and genotype as important factors. **Objective:** Describe a testing model to determine if genotype and head impact acceleration affect response to head impact. **Design:** A descriptive study. **Setting:** Laboratory. **Patients or other Participants:** Fourteen male and female soccer players (age = 21±2.0 years, height = 170.5 cm ±14.5, weight = 71.8 ± 19.7 kg) with at least 5 years of heading experience and no recent head or neck injury. All participants completed IRB approved informed consent and HIPAA compliance forms prior to data collection. **Interventions:** The independent variables were group (experimental vs. control) and time (pre-test, and 1, 24, and 48 hours post-test). Participants had whole blood samples drawn to assess their APOE genotype (E2, T471C; E4, C609T; promoter, G-219T). A concussion signs and symptoms checklist was completed before and 1, 24, & 48 hours post heading. The experimental group performed 10 soccer headers and the control group performed 10 simulated headers (i.e., no head impacts). A custom mouthpiece with triaxial accelerometer affixed was used to assess head acceleration during the headers or simulated headers. A soccer ball was projected at 11.2 m/s a range of 11m at participants. Data were analyzed with descriptive statistics using SPSS 17.0. **Main Outcome Measures**: The dependent variables were head kinematics (peak and total linear resultant acceleration), number of self-reported concussion signs and symptoms, and APOE genotype (E2, E4, and promoter rare allele present vs. not present). **Results:** Peak head impact accelerations ranged from 17.17 – 31.27 g and head impact acceleration total ranged from 144.45 – 212.57 g. Six (all possessing the APOE promoter rare allele) of 8 experimental group members and 2 of 6 control group members reported at least 1 post-test concussive sign or symptom. At 48 hr post-test, 5 experimental group members reported at least 1 sign or symptom, with 50% reporting 3 or more. A participant carried each polymorphism rare allele, experienced the greatest amount of head acceleration (peak = 31.27 g and total = 212.57 g) and reported the most signs and symptoms 48 hours post heading (7); whereas, another participant carried no rare alleles, experienced the lowest

amount of head acceleration and did not report any signs and symptoms. **Conclusions:** Consistent with previous literature, our results suggest that individuals respond differently to similar head impacts. This variability may be due to environmental (head impact acceleration) and genetic factors. Future research using this model incorporating a greater sample size and other concussion assessment measures (e.g., postural stability or computer based neuropsychological testing) could further elucidate the factors contributing to variable response to head impacts and brain injury susceptibility.

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**Neuronal Structural Protein Polymorphism And Concussion In College Athletes**

McDevitt J, Tierney RT, Mansell JL, Driban J, Higgins M, Toone N, Mishra A, Krynetskiy E: Temple University, Philadelphia, PA; Lincoln University, PA; Towson University, Towson, MD

**Context**: Neuronal structural proteins (e.g., neurofilament heavy [NEFH]) provide structural integrity to neurons. Genetic variation (e.g., single nucleotide polymorphism [SNP]) can change a protein's structure and alter a cell's structure and function. Carrying a rare allele for a NEFH SNP could affect a person's susceptibility to neuronal injury following a head impact. There has been no research performed on the association between carrying a NEFH SNP rare allele and concussion occurrence or severity. **Objective**: Examine the association between carrying a NEFH SNP rare allele and concussion occurrence and severity in collegiate athletes. **Design**: Case control. **Setting**: Three NCAA athletic facilities. **Participants**: Forty-nine athletes with self-reported history of a concussion (age 19.30 ± 1.33 years and height 179.73 ± 10.95 cm) were matched by sport, position, age, and height with 49 healthy controls (age 19.88 ± 1.42 years and height 181.30 ± 8.37 cm). Groups were based *a priori* on pathologic outcome of concussion. Participants completed IRB approved consent and HIPAA forms prior to data collection. **Interventions**: All participants completed a concussion history questionnaire and were genotyped via saliva sample for the NEFH missense SNP rs#165602 (A2414C). The independent variables were group (self reported history of concussion vs. no history of concussion) and NEFH genotype (AA vs. AC or CC, where A is the common and C is the rare allele). A 2 (group) x 2 (genotype) chi square was used to identify the association between NEFH genotype and concussion occurrence. Independent t-tests were used to assess severity data difference across genotypes (AA vs. AC or CC) within the concussed group. SPSS 17.0 was used for all analyses, and the alpha level was set at $p \leq .05$. **Main Outcome Measure(s):** Dependent variables were self-reported history of concussion occurrence and severity. Severity was assessed by examining concussion signs and symptom duration and length of time until return to play. **Results**: The chi-square revealed no significant association ($x^2 = .487$, $p = .485$) between carrying the NEFH rare allele and a history of concussion. Eleven percent of those with a previous concussion carried the rare allele compared to 35% of controls. Independent t-tests revealed no significant differences in concussion signs and symptom duration (0.79 ± 2.24 vs. 1.78 ± 8.10 days), $t(1,48) = 2.054$, $p = .159$, or RTP time (2.47 ± 8.57 vs. 2.96 ± 10.52 days), $t(1,48) = .245$, $p = .623$, between NEFH rare allele carriers and non-carriers. **Conclusions:** This is the first examination of the possible association between an NEFH SNP rare allele and concussion. Carrying the rare allele assessed in this study does not seem to influence an athlete's susceptibility to sustaining a concussion, or the signs and symptoms duration and return to play time following concussion.

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# EBF: Heat & Hydration

Thursday, June 24, 2010, 8:15AM-9:15AM; Discussants: Sandra Fowkes Godek, PhD, ATC, and J. Dugas; Moderator: Arthur Bartolozzi, MD

# Free Communications, Oral Presentations: Hydration Interventions

Thursday, June 24, 2010, 9:15AM-10:15AM, Room 202AB; Moderator: Michelle Cleary, PhD, ATC

**Comparison Of *Ad Libitum*, Oral, Intravenous, And Combination Rehydration: Thermoregulatory Function And Perception Following Exercise Dehydration**

McDermott BP, Casa DJ, Beasley KN, Emmanuel H, Lee EC, Yamamoto LM, Anderson JM, Pescatello LS, Armstrong LE, Maresh CM: Graduate Athletic Training Program, University of Tennessee at Chattanooga, Chattanooga, TN; Human Performance Laboratory, University of Connecticut, Storrs, CT; Yale University School of Medicine, New Haven, CT

**Context:** Athletic trainers recommend and utilize a multitude of rehydration (REHY) methods. There is a lack of scientific evidence supporting a superior REHY mode to correct exercise dehydration (EXDE). **Objective:** To compare the effects of the five most common REHY methods on thermoregulatory and perceptual restoration following EXDE. **Design:** Randomized, cross-over, control comparison. **Setting:** Controlled laboratory with environmental chamber (35.5 ± 1.5°C, 33 ± 8% relative humidity). **Patients or other participants:** Twelve physically active subjects (23 ± 4 yrs, 81.3 ± 3.7 kg, 180 ± 6 cm, 56.9 ± 4.4 $mL \cdot min^{-1} \cdot kg^{-1}$ $VO_2$max, 7.9 ± 3 % body fat) voluntarily participated in five experiments. **Interventions:** Subjects completed 20-hr fluid restriction and 2-hr EXDE (treadmill walking and cycle ergometry), then received no fluid (NF), were provided *ad libitum* (AL) or metered (2% body mass) amounts of ½-normal saline (0.45% NaCl) via oral (OR), intravenous (IV), or a combination of ½IV and ½OR (IV+OR) within 30-min. OR and IV fluids were evenly spaced throughout the 30-min REHY period and were the identical temperature for all trials (19°C). Subjects were observed for a total of 60-min (30-min REHY and 30-min seated observation). The fluid for AL, OR, and IV+OR trials was non-calorically lemon flavored (Supervalu, Inc., Eden Prarie, MN), with identical electrolyte concentration and temperature as the IV fluid. **Main outcome measures:** Body mass, rectal temperature, 4-site mean weighted skin temperature, sweat rate, plasma cortisol concentration [CORT], thermal sensation and Environmental Symptoms Questionnaire (ESQ) score. **Results:** Subjects were hypohydrated (-4.23% body mass) post-EXDE and were REHY to -2.13 ± 0.47% for all but NF and AL trials. Subjects partially REHY during AL, returning to only -2.13 ± 1.3% body mass. Funded by the NATA Foundation Doctoral Research Grant Program.

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NF rectal temperature was significantly greater than IV (p=.023) at REHY30, and significantly greater than OR, IV, and IV+OR (p≤.009), but not AL (p=.068) at REHY60. Mean weighted skin temperature during AL was significantly less than IV+OR at REHY5 (p=.019). Sweat rate throughout REHY and seated recovery did not differ between REHY mode and averaged 0.96 ± 0.18 L·hr$^{-1}$ (p=.699). AL demonstrated increased plasma [CORT] compared to IV+OR, independent of time (p=.015). Thermal sensation showed a significant decrease over time (p<.05), without a significant between trial difference (p=.324). NF ESQ score was significantly greater than IV+OR at REHY60 (p=.012), but no other significant differences existed. **Conclusions:** IV and combined IV+OR REHY offered some short-term thermoregulatory advantages over NF and AL REHY, beyond those of OR REHY. These benefits were equivocal after 30-min of recovery. IV+OR attenuated environmental symptoms more effectively than other REHY modes. Combining IV+OR REHY stimulates multiple mechanisms of thermoregulatory recovery following EXDE.

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**Hydration In Acclimatized Adolescent Female Athletes Before And After An Educational Intervention**

Gard DL, Cleary MA, Hetzler RK, Kimura IK, Stickley CD, Wages JJ: Department of Kinesiology and Rehabilitation Science, Human Performance Research Laboratory, University of Hawaii at Manoa, Honolulu, HI

**Context:** Education on the integration of proper hydration techniques during competitive exercise conditions for adolescent athletes is important in the prevention of exertional heat illness. Evidence supporting the use of an educational intervention on modification of hydration behaviors in adolescents during physical activity is limited. **Objective:** The purpose of this study was to identify changes in hydration behaviors before and after Educational and Prescribed Hydration Interventions in acclimatized female adolescent volleyball players. **Design:** A repeated measures design. **Setting:** Participants were observed during five periods (3 practices/week) of competitive volleyball practices in an un-air-conditioned gymnasium in a warm, humid sub-tropical environment ($WBGT_i$ range = 21.1–26.7°C, mean= 24.0±3.9°C). **Participants:** Participants were 40 female adolescent athletes competing in high-level volleyball club (age=14.8±0.8 y, height= 168.2±8.2 cm, weight=60.9±9.0 kg). **Interventions:** Four observation periods: control period, Post-Educational Intervention, Prescribed Hydration Intervention, and Post-Prescribed Hydration Intervention periods. After the initial observation period (control), an Educational Intervention consisting of a computer generated slideshow presentation and an informational handout were provided. The Prescribed Hydration Intervention consisted of participants consuming a minimum of a pre-calculated volume of water matched to individual sweat rates every 20 min during each two hour practice. **Main Outcome Measures:** The independent variables were intervention periods (control, Post-Educational Intervention, Prescribed Hydration Intervention, and Post-Prescribed Hydration Intervention). The dependent variables were pre- to post practice changes (Δ) in hydration status measured by percent body mass loss (BML); urine specific gravity ($U_{sg}$), urine color ($U_{col}$), and urine osmolality ($U_{osm}$); sweat rate (SR); and volume of fluid consumed ($F_{vol}$). Environmental conditions were recorded using a wet bulb globe temperature indoor ($WBGT_i$) monitor during the first 15 min and last 15 min of practice. Participants completed an Environmental Symptoms Questionnaire (ESQ) at the conclusion of practice with two questions used for data analysis and correlated to $WBGT_i$. **Results:** The Prescribed Hydration Intervention was the only period where participants did not lose body mass (BML=0.1±3.2%) and resulted in the highest sweat rate (SR=0.72±0.25L/hr, $p$≤.001), highest fluid consumed ($F_{vol}$=1.34±0.39 L, $p$≤.001), and the largest decrease in $U_{osm}$ ($\Delta U_{osm}$=-303±116mmol/L, $p$≤.001). The Post-Prescribed Hydration Intervention period had the largest decrease in body mass (BML=-1.2±1.9%, or -0.7±1.9kg, $p$=.044) and the largest increase in urine concentration ($\Delta U_{col}$=0.6±0.4 shades, $p$=.007; $\Delta U_{sg}$= 0.619±0.412 µg, $p$=.042). A strong correlation (r=0.99) was found for WBGTi between the first 15 min of practice and the last 15 min of practice whereas weak relationships were found for WBGTi and the ESQ question scores for the "I felt hot" (r=0.10) and "I felt thirsty" (r=0.12). **Conclusions:** Adolescent female athletes were only able to maintain hydration status during exercise in a warm, humid environment with a prescribed hydration protocol. Education alone was ineffective in changing rehydration behaviors.

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**Examining The Influence Of Hydration Status On Physiological Responses And Running Speed During Trail Running In The Heat With Controlled Exercise Intensity**

Lopez RM, Casa DJ, Jensen K, DeMartini J, Pagnotta K, Stearns RL, Hanewicz K, Marzano S, Roti M, Ruiz R, Yamamoto LM, Armstrong LE, Maresh CM: University of Connecticut, Storrs, CT

**Context:** Disparities in fluid replacement guidelines for exercising individuals arose from inconsistencies between laboratory and field studies. Controlled field studies are needed to determine the influence of hydration on physiological function. **Objective:** To determine the effects of dehydration at a controlled relative intensity on physiological responses and trail running speed. **Design:** Randomized, controlled crossover design. **Setting:** Field study (trails) in warm environment (mean ± SD: WBGT:27.6 ±1.3°C). **Patients or Other Participants:** Fourteen (7 female; 7 male) competitive, well-trained endurance runners (age= 29.8±10.4 y, height= 172.9±7.4 cm, body mass= 66.7±11.8 kg, 14.31±6.6 %BF) from the local community. **Interventions:** Participants completed two submaximal trials: a hydrated (HY) and a dehydrated (DHY) condition. For each trial, subjects ran three laps (4-km·lap$^{-1}$, 12-km total) on trails with four-minute rests between laps. DHY consisted of fluid restriction 22-h prior to the trial and during the run. In HY, subjects arrived euhydrated and were given fluids during rest breaks. Subjects ran at a moderate pace that was matched between trials by providing pacing feedback via heart rate (HR) throughout each lap of the second trial. Gastrointestinal temperature ($T_{GI}$) and HR were continually monitored. Total time and lap times were recorded. Data were analyzed with repeated measures ANOVA with Bonferonni corrections when appropriate. Paired-samples t-tests were used to further evaluate differences. Significance was set at p≤0.05. **Main Outcome Measures:** Percent body mass (BM) loss, HR, $T_{GI}$, time, ratings of perceived exertion (RPE). **Results:** Percent BM losses were significantly greater for DHY pre-trial (-1.7±1.3%) than HY (0.0±1.3%) compared to a 3-day euhydrated baseline BM (p<.001). Post-trial, DHY BM losses (-3.6 ±1.3%) were significantly higher than HY (-1.4±1.4%; p<.001). No significant differences existed in HR between conditions (p>0.05). Significant time effects existed for $T_{GI}$ in both conditions (p<.001). A significant main effect in $T_{GI}$ (p=.009) for hydration was found with the DHY condition having significantly higher $T_{GI}$ post-run (DHY:39.09 ±0.45°C, HY:38.71 ±0.45°C; p=.030), 10-min post (DHY:38.85

±0.48°C, HY:38.46 ±0.46°C; p=.009), and 30-min post (DHY:38.18±0.41°C, HY:37.60 ±0.25°C; p=.000). Time was not significantly different between conditions after Lap 1 (DHY:1240±133 s, HY:1234±128 s; p=.771) but DHY resulted in significantly slower run times after Lap 2 (DHY:1311±171 s, HY:1269±162 s; p=.019) and Lap 3 (DHY: 1354±185 s, HY:1302±185 s; p=.025). Overall, DHY resulted in completing the 12-km run 99 seconds slower than HY (p=0.027). RPE was higher in DHY for every time point during running, and approached significance at the post-run time point (p=0.055). **Conclusions:** These findings suggest that exercising while dehydrated and when relative intensity is controlled could result in slower run times and elevated $T_{GI}$. The negative impact of the 2.2% BM loss difference between conditions is meaningful, particularly for athletes using HR as a gauge for exercise effort and performance.

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**Validity Of Baseline Body Mass Measurement Among Various Levels Of Football**

Yeargin SW, Eberman LE, Falconer SK, Vaal TL: Indiana State University, Terre Haute, IN

**Context:** Athletic trainers commonly use "weight charts" during pre-season practices to monitor fluid losses in football players (FBP). However, if the baseline body mass measurement (BBM) is not valid, clinicians may underestimate fluid loss calculations. **Objective:** To determine if FBP report to pre-participation examinations (PPE) hydrated and to compare different levels of FB teams. Researchers hypothesized that the majority of BBM would be invalid due to dehydration, High School (HS) FBP would be more dehydrated than all other levels, and veteran status would influence hydration. **Design:** Cross sectional analysis. **Setting:** Separate PPEs for professional(Pro), division I collegiate(DI), division III collegiate(DIII), and HS FB teams. **Patients or Other Participants:** Male FBP(n=288) participated in a hydration station at their respective PPEs: Pro(n=48, 3±2years experience[ye]), DI(n=88, 2±1ye), DIII(n=85, 2±1ye), and HS(n=67). FBP represented all playing positions. **Interventions:** FBP arrived at the hydration station, signed informed consent, were weighed for BBM, provided a urine sample, and demographic info (player position, veteran status). **Main Outcome Measures:** Four investigators analyzed the samples for urine specific gravity (Usg) via a clinical refractometer (Inter-rater reliability for ICC=0.97, $P$<0.001; Intra-rater reliability ICC range=0.98-0.99, $P$<0.001). BBM was measured on a calibrated scale with the FBP wearing only shorts. Athletes were considered hydrated if USG<1.020, moderately dehydrated if USG=1.020-1.029, and significantly dehydrated if USG≥1.030. Levene's statistic (P=0.201) indicated heterogeneity. A one-way ANOVA identified differences between participation levels and Usg. Separate Kruskal Wallis tests (non-parametric one-way ANOVA) identified differences between participation levels, team veteran status, and position on hydration status. Significance was set a-priori, $P$<0.05. **Results:** A majority of athletes were moderately(n=131, 45.5%) or significantly dehydrated(n=44, 15.3%) at the PPE. Significant differences were revealed between participation levels for hydration status(H=49.27, d.f.=3, $P$<0.001). A little less than half of Pro(47.8%, n=23/48) and HS(44.7%, n=38/85) FBP were moderately or significantly dehydrated at the PPE. More than half of the DIII(61.2%, n=41/67) and more than three quarters of the DI(83.0%, n=73/88) FBP were moderately or significantly dehydrated. Significant differences were found between participation levels for Usg (mean= 1.021±0.008, $F_{3,284}$=20.28, $P$<0.001). Post-hoc analyses indicated that DI(1.026±0.007) were significantly more dehydrated than the other levels of FBP (Pro mean=1.017±0.008, $P$<0.001; DIII mean=1.018±0.008, $P$<0.001; HS mean= 1.020±0.008, $P$<0.001). No significant differences were found between veteran status(H=0.96, d.f.=3, $P$=0.811) and position(H=1.50, d.f.=5, $P$=0.913) among the Pro, DI, and DIII FBP USG and hydration status. **Conclusions:** The invalid BBM hypothesis was supported with approximately half of FBP arriving to PPE dehydrated no matter FB participation level. Clinicians should be aware that they may underestimate fluid losses during pre-season as a consequence. Our hypotheses about HS FBP and veteran status were not supported by the results. Clinicians therefore cannot rely on participation level nor veteran status to encourage better hydration status at PPE.

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## Free Communications, Oral Presentations: Thermoregulation & Sweat Variables

Thursday June 24, 2010, 10:30AM-11:30AM, Room 202AB; Moderator: Lindsey Eberman, PhD, ATC

**Higher Sweat Rates In White Compared To Black NFL Players Matched By Body Size And Position But No Differences In Sweat Sodium**

Condon S, Fowkes Godek S, Peduzzi C, Burkholder R, Borgmann A, Bartolozzi AR: Philadelphia Eagles, Philadelphia PA; HEAT Institute at West Chester University, West Chester, PA; Pennsylvania Hospital, Philadelphia, PA

**Context:** We previously studied sweat sodium concentration [$SwtNa^+$] in professional football players (NFL) and made racial comparisons but we had a small group, and in order to have an adequate number of white players to match with the black cohort we included a group of white collegiate players. Due to potential differences in exercise intensity between the NFL and collegiate players this could have skewed the sweat rate data. **Objective:** To compare sweat rate (SwtR) and [$SwtNa^+$] in black and white NFL players matched by height, mass and body surface area (BSA). We hypothesized that no differences in SwtR or [$SwtNa^+$] would be found. **Design:** Observational cohort. **Setting:** Two consecutive training camps (2007 and 2008) of one NFL team. **Patients or Other Participants:** Eighteen black (age =26.6±3y, height =187 ± 7cm, mass = 115 ±26kg and BSA =2.39±.27$m^2$) and 18 white (age=26.4 ±3y, height=189 ±7cm, mass=113 ±21kg and BSA=2.39± .24$m^2$) players volunteered. **Interventions:** After the skin of the right upper forearm was prepped with alcohol and deionized water, a sterile sweat patch was applied and secured with impermeable tape. The patches where removed during practice, placed in sterile, siliconized tubes and centrifuged on site. The sweat samples were frozen and later analyzed using flame photometry. SwtR was calculated by change in mass adjusted for fluids consumed and urine produced divided by practice time. **Main Outcome Measures:** SwtR, [$SwtNa^+$], sweat sodium losses, fluids consumed and urine volume. Comparisons were made using independent t-tests and significance was set at $P$<.05. **Results:** SwtR were higher in white (1.97± .6 l/h) compared to black (1.56 ± .4 l/h) players, $P$ <.03. There were no differences in [$SwtNa^+$] between black (52±21 mmol/l, range =15 to 85 mmol/l) and white (47±25 mmol/l, range= 23 to 99 mmol/l)

players (*P*= .5) or in $Na^+$ loss per h, fluid consumed or urine produced. **Conclusions:** The never reported finding of higher sweat rates in size matched white NFL players is interesting with the 21% difference likely clinically relevant. However, this data is difficult to interpret without core temperature and VO2 data which will require a laboratory study. If there were no differences in core temperature at the same $VO_2$ it is possible that black players lost heat more effectively than white players. If the core temperatures were higher in black athletes then they may have been regulating their body temperatures at a higher threshold resulting in lower sweat rates. Evolution could explain both justifications. It is possible that the large individual variability of both [Swt$Na^+$] and SwtR resulted in the insignificant finding of $Na^+$ loss between the black (1.85 ± .88 g/h) and white (2.26 ± 1.69 g/h) players, although this is likely clinically important.

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**Appearance Of $D_2O$ In Sweat During Recovery And Exercise-Heat Stress Following Oral And Oral-Intravenous Rehydration**

Emmanuel HE, Casa DJ, Beasley KN, Lee EC, McDermott BP, Yamamoto LM, Armstrong LE, Maresh CM: University of Connecticut, Human Performance Laboratory, Storrs, CT

**Context:** Intravenous (IV) rehydration is a common practice in athletics, however its thermoregulatory benefits and ergogenicity have not been elucidated. The availability of orally ingested fluid is dependent on the rate of gastric emptying and intestinal absorption. Deuterium oxide ($D_2O$) has been utilized as a tracer to demonstrate that fluid ingested during exercise appears in sweat within the first 10 minutes after drinking. **Objective:** The purpose of this study was to determine whether simultaneous IV rehydration alters the appearance of oral fluid traced with $D_2O$ in the sweat. It is unknown whether increasing plasma volume directly via IV fluid administration alters gastric emptying and/or intestinal absorption. We hypothesized that bypassing the oro-pharengeal receptors as well as those in the stomach with 50% of the fluid may limit the potential benefits of immediate entry into the systemic vasculature. **Design** randomized, cross-over, control comparison **Setting:** All experimental trials took place in an environmental chamber (35.6±0.2°C, 35.0±1.8% relative humidity). **Patients or Other Participants** Ten healthy, fit males (age 23±4,$VO2_{max}$ 59.49±4.09L/min) were recruited from the University of Connecticut and surrounding areas. **Interventions:** Subjects underwent 20 hours of fluid restriction resulting in 1.95±0.25% body weight loss before beginning treadmill exercise for 2 hours at ~55%$VO_{max}$. By the end of this exercise bout, mean body weight deficit was 4.50±0.04%. Thermoregulatory measures were recorded while subjects rehydrated back to 2.33 ± 0.93% with oral(OR) or oral combined with intravenous (OR+IV) fluid during a 30 min seated recovery period. The oral fluid was a non-caloric, flavored (Light Lemonade, Supervalu, Inc., Eden Prarie, MN), electrolyte (0.45% NaCl) beverage, and the IV fluid was half-normal saline (0.45% NaCl). Fluid was delivered in equal boluses every 5 minutes. The initial orally ingested fluid bolus was mixed with $D_2O$ (0.15 $ml \cdot kg^{-1}$, Cambridge Isotope Labs, Andover, MA). Following 30 minutes (min) rehydration and 30 min seated recovery, subjects began a 25 min of treadmill exercise at 55-60% $VO2_{max}$. **Main Outcome Measures:** Forehead sweat samples were collected 0, 5, 10, 20, and 75(15 minutes into the subsequent exercise bout) min from the start of rehydration. Samples were analyzed for $D_20$ via isotope ratio mass spectrometry. A two-way repeated measures ANOVA was used(treatment X time). **Results:** No significant differences were found between the two modes of rehydration (p=0.275). **Conclusions:** The presence of $D_2O$ in the sweat was not significantly different with OR+IV and OR rehydration when subjects were dehydrated and at rest during recovery from exercise in the heat. Furthermore, no difference was noted between OR+IV and OR in the subsequent exercise bout. Increasing plasma volume directly and decreasing the size of the orally ingested fluid bolus did not appear to significantly alter transit time from mouth to the eccrine sweat gland.

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**Implications Of Altered Ingestion Times And Cool Water Consumption On The Validity Of Temperature Sensors**

Hernandez AE, Yeargin SW, Eberman LE, Moore AW, Casa DJ, Edwards JE, Parsley EJ, Abe H: Athletic Training Department, Indiana State University, Terre Haute, IN; New Hampshire Musculoskeletal Institute, Manchester, NH; University of Connecticut, Storrs, CT

**Context:** Exertional heat illnesses may be prevented through timely and accurate measures of core body temperature (CBT). The ingestible sensor (IS) has been identified as a valid measure of CBT as compared to a rectal thermometer (RT). However, the extent to which sensor validity is effected by differing sensor ingestion times and drinking cool water in individuals remains poorly understood. **Objective:** Assess the validity of the IS when ingested at varied times with cool water consumed throughout the trials. **Design:** Randomized, repeated measure within group design. **Setting:** Environmental chamber (mean temperature=23.6±1.2°C). **Participants:** Eleven males and five females (age 22±3yrs; weight 71.1±12.3kg; height 173.8±8cm) participated in the active exercise trial. Eight males and eight females (age 23±5yrs; weight 76.7±19.0kg; height 168.8±10.2cm) participated in the passive trial. **Interventions:** Active and passive individuals completed three trials, one for each ingestion time (30 minutes, 1 hour, 2 hours), the independent variable. Subjects swallowed an IS at the allocated time prior to data collection and self-inserted a RT 10 minutes before data collection. Subjects in the active group consumed 200mL of water every 15 minutes while walking on a treadmill in the environmental chamber for 3 hours at a 5% grade at 3.0-3.5 mph pace. The passive group remained seated in the environmental chamber and drank 100mL of water at 15-minute intervals for the 3-hour session. **Main Outcome Measures**: CBT was measured throughout the data collection sessions using both the IS and RT; 4 time intervals (0 min, 60 min, 120 min, and 180 min) were used for data analysis. Separate, repeated measures analyses of variance were used to identify differences between the RT and IS across trials (3 trials) and time (4 measures) in both groups. **Results:** Significant differences were found ($F_{1,15}$=21.64, p<0.001, ES=0.59) between rectal (mean=37.50±0.07°C) and ingestible (mean=36.60±0.17) temperatures in active individuals. Significant differences were also found ($F_{1,15}$=52.41, p<0.001, ES=0.78) between rectal (mean=37.21±0.06°C) and ingestible (mean=36.31±0.12) temperatures in passive individuals. There were no significant differences between sensor ingestion time trials in the active ($F_{2,30}$=1.22, p=0.31, 1-β=0.25) or passive ($F_{2,30}$=0.88, p=0.42, 1-β=0.19) groups. **Conclusions:** The IS is invalid when ingested 30 minutes, 1 hour, and 2 hours prior to obtaining CBT in both active and passive individuals while consuming cold water at 15-minute increments in indoor heat. Clinicians should have their athletes ingest the IS at least 5 hours prior to measuring CBT.

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**The Effect Of Uncompensable Heat Stress On Physiological Measures And Termination Of Exercise**

Emerson CC, Torres-McGehee TM, Minton DM, Stacy JJ: Department of Exercise Science, Exercise Biochemistry Laboratory, University of South Carolina, Columbia, SC; North Carolina State University, Raleigh, NC; Department of Physical Education, University of South Carolina, Columbia, SC; Department of Orthopaedic Surgery, University of South Carolina, Columbia, SC

**Context:** Exercise in the heat causes physiological changes which can indicate decreased performance or lead to exertional heat illness. Understanding the signs of heat stress is important to determine safe guidelines for termination of exercise. **Objective:** To examine the effects of uncompensable heat stress on physiological measures and termination of exercise. **Design:** Randomized, crossover design. **Setting:** Controlled laboratory experiment in an environmental chamber. **Patients or Other Participants:** Ten euhydrated, sodium-balanced participants (6 male, 4 female, age=27.9 ± 7.76 years, height= 172.72 ± 12.54 cm, mass= 70.27 ± 15.79 kg) completed this study. **Intervention(s):** Participants completed two exercise trials: a control trial (C) in temperate conditions, and a heat stress trial (HST) in hot, humid conditions. Participants exercised at 2.25 m/s on a treadmill until volitional fatigue or core temperature of 40°C was reached. **Main Outcome Measure(s):** Body mass was measured pre-, post-, and after every 15 min of exercise. Heart rate and core temperature were assessed pre-exercise and after every 5 min of exercise. Blood samples were collected to assure sodium balance (plasma [Na+] > 140 mmol/l) pre-, post-, and after every 30 min of exercise. Urine samples were collected to assure hydration (urine specific gravity > 1.020) pre-end post-exercise. $VO_2$max was estimated from 12 min run distance. Physiological strain index (PSI) was calculated using heart rate and core temperature data at all time points. **Results:** Of the ten participants who completed the HST, seven were terminated due to volitional fatigue, and three were terminated due to core temperature. Time to termination (TTT) was decreased in the HST (34.5±8.3 vs. 117.5±62.5, p=0.035). Core temperature at 45 min (39.99±0.06 vs. 38.18±0.27, $p$<0.001) and heart rate at 30 min (163±12 vs. 147±13, $p$=0.034) were higher during the HST. PSI was higher in the HST at 45 min (9.44±0.24 vs. 5.55±1.07 $p$=0.009) and at termination of exercise (9.24±2.05 vs. 6.23±1.25, $p$=0.011). Four subjects scored higher than 10 on the PSI (maxPSI=11.81). $VO_2$max had a positive relationship with TTT in both the C ($r$=0.951, $p$=0.004) and HST ($r$=0.719, $p$=0.019). TTT had negative relationships with PSI ($r$=-0.599, $p$=0.018) and core temperature ($r$=-0.707, $p$=0.003) at termination. **Conclusions:** Environment had a negative effect on physiological measures and time to termination. Physiological strain index scores were higher than previously reported for euhydrated individuals. Individuals were able to achieve high core temperatures and levels of physiological strain prior to volitional fatigue. Monitoring these variables and understanding their context is important for those who exercise in the heat.

# Free Communications, Oral Presentations: Core Training & Activation

Thursday June 24, 2010, 4:30PM-5:45PM, Room 202AB; Moderator: Anthony Kulas, PhD, LAT, ATC

**The Effect Of An Eight-Week Training Program On Abdominal Muscle Thickness**

Gage MJ, Hopkins JT, Seeley MK, Draper DD, Hunter I, Feland JB, Myrer JW, Sudweeks RR: Indiana State University, Terre Haute, IN, and Brigham Young University, Provo, UT

**Context:** Strong lumbo-pelvic muscles may decrease the risk of lower extremity injuries. Increased muscle size represents strength gains. Morphological changes have not been observed in the following abdominal muscles: rectus abdominis (RA), transverse abdominis (TrA), external (EO) and internal oblique (IO). **Objective:** Determine if: 1) abdominal muscle thickness differed between groups pre-training and 2) morphological changes occur in the abdominal muscles during eight weeks of training in healthy and chronic ankle instability (CAI) subjects. **Design:** A 3 x 5 (group x time) cohort design. **Setting:** Controlled laboratory. **Patients or Other Participants:** Nineteen Control (age = 22±3 yrs, mass = 74.1±13.8 kg, height = 172.6±11.3 cm, BMI = 24.8±3.1%), 21 CAI (age = 22±2yrs, mass = 77.6±14.0 kg, height = 175.4±12.3 cm, BMI = 25.1±2.6%), and 20 healthy (age = 23±3yrs, mass = 70.9 ±15.6 kg, height = 172.2±8.9 cm, BMI = 23.7±3.3%) subjects participated. Chronic ankle instability subjects self-reported a history of CAI and functional ankle instability. The Ankle Instability Index and Functional Ankle Ability Measure confirmed CAI and functional ankle instability respectively. **Interventions:** The CAI and healthy groups participated in an eight week abdominal training program while the control group maintained their activities of daily living and fitness level. Muscle thickness was measured using ultrasound imaging at 0, 2, 4, 6, and 8 weeks. **Main Outcome Measures:** The dependent variable was abdominal muscle thickness. A repeated measures ANOVA was used to analyze abdominal muscle thickness pre- and post-training. Post-hoc testing with a Bonnforoni adjustment determined differences between and within groups. **Results:** Mean muscle thickness (mm) was measured pre- (Control - RA;10.7±1.9: EO;6.1±1.2: IO; 9.4±2.2: TrA; 3.8±0.9: CAI - RA;11.9±2.9: EO; 6.7±1.6: IO;10.0±3.3: TrA; 4.0±1.3: Healthy - RA;11.3±2.5: EO;6.3±1.4: IO; 9.2±2.5: TrA; 3.6±0.7) and post-training (Control - RA;10.7±2.0: EO;6.2±1.3: IO; 9.2±2.2: TrA; 3.7±0.9 : CAI - RA;12.8±2.9: EO; 7.9±2.1: IO;9.7±2.1: TrA; 3.8±0.9: Healthy - RA;12.9±2.8: EO;7.3±1.9: IO; 9.6±2.8: TrA; 3.7±0.8). No differences existed between groups pre-training (RA; $F_{(57, 2)}$= 1.17, $p$ = 0.318: EO; $F_{(57, 2)}$= 0.77, $p$ = 0.468: IO; $F_{(57,2)}$= 0.55, $p$ = 0.582: TrA; $F_{(57,2)}$= 1.16, $p$ = 0.319). Post-training an interaction was present between RA thickness & group ($F_{(8, 4)}$= 4.07, $p$< 0.001). External oblique thickness increased in the CAI ($p$< 0.001) and healthy ($p$ = 0.002) groups. No thickness changes were observed in IO ($F_{(8, 4)}$= 0.33, $p$ = 0.857) and TrA ($F_{(8, 4)}$= 4.77, $p$ = 0.012). **Conclusions:** Morphological changes were observed in the RA and EO after eight weeks of training but not in the IO and TrA. Abdominal training programs should be eight weeks or longer to ensure RA and EO strengthening through morphological change. Chronic ankle instability does not affect abdominal muscle thickness.

**The Effects Of A Six-Week Core Stabilization Training Program On Core Endurance In Ice Hockey Club Sport Athletes**

Sandrey MA, Matlage JM: West Virginia University, Morgantown, WV, and Carolina Panthers, Charlotte, NC

**Context**: Core stabilization is important in ice hockey, however, very little can be found in the literature as to which specific training program to use that will improve core endurance. **Objectives**: To examine the effects of a six-week core stabilization training program on core endurance. **Design**: Pre-test/post-test, repeated measures design. **Setting**: Sports Medicine Facility **Patients or Other Participants***:* The experimental group (EG) consisted of 15 healthy ice hockey club sport athletes (19.30±1.49 yrs, 176.15±6.81 cm, 76.99±8.18 kg) using a sample of convenience. The control group (CG) of 19 (19.15±1.39 yrs, 179.96±7.38 cm, 84.82±7.34 kg) consisted of healthy lacrosse club sport athletes that were matched to the age and activity levels of the EG. **Interventions**: The EG performed the six-week supervised program two times a week for an average of 30 minutes/session. The three-level core stabilization training program consisted of exercises sport specific to ice hockey demands, which were increased in difficulty each week by adding more challenging exercises, repetitions, or decreasing stability. Subjects began using level one exercises and progressed to level two and three exercises by increasing time, sets/reps weekly. The control group performed no exercises. Pre/post testing included the Back Extensor Test (BET), 45° Abdominal Fatigue Test (AFT), and Right and Left Side Bridging Test (SBT). Analyses consisted of group and test (BET, AFT), and group, side and test (SBT) repeated measures ANOVA (P=0.05). **Main Outcomes Measures**: The AFT, BET, and SBT for both sides timed in seconds. **Results**: Percent improvement ranged from 5.80% to 136.89% with SBT demonstrating the greatest increase. For the AFT (P<.001) and BET (P<.001) there was a test by group significance with the EG>CG times at post-test. Two significant interactions for the SBT were evident for test by group (EG>CG times at post-test, P=.017) and side by group (EG>CG for right and left SBT, P<.001). Post-test times were significantly higher than pre-test times for the AFT (P<.001), BET (P<.001) and SBT (P<.001). The right SBT time increased more than the left SBT time (P<.001). The EG times were significantly higher than CG for the AFT (80.80±26.67/49.34±14.21, P=.031), BET (122.00±23.28/56.68±12.84, P<.001), and SBT (P<.001) for right SBT (90.57±16.7/45.86±11.71) and left SBT (84.57±17.26/45.22±10.99). No other results were significant. **Conclusion**: There was a significant difference between the EG and the CG with the EG showing substantial improvements between pre/post AFT, BET and SBT times after the six-week training. Our data does support the use of this core-stabilization training program to increase core endurance in ice hockey club sport athletes.

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**No Differences In Transverse Abdominis Activation Ratio Between Healthy And Low Back Pain Patients During Therapeutic Exercises**

Gorbet N, Selkow NM, Hart JM, Saliba S: Exercise and Sport Injury Laboratory, University of Virginia, Charlottesville, VA

**Context:** Low back pain (LBP) is a very common condition. Despite the focus on core strengthening during rehabilitation, LBP has a high recurrence rate. Dysfunction of the transverse abdominis (TrA) has been associated with LBP and several therapeutic exercises have been prescribed to help target the TrA. These exercises include the abdominal drawing-in maneuver (ADIM) and quadruped exercise. Ultrasound imaging (USI) has been used previously to capture activation of the TrA in healthy people. **Objective:** To examine TrA activation during ADIM and quadruped exercises between healthy and LBP patients. **Design:** Case control. **Setting:** Sports medicine laboratory. **Patients and other Participants:** Sixty subjects volunteered to participate; 30 healthy (H) (Age 21.41±.56 years; Height 174.65±1.82cm; and Weight 74.45±2.71kg) and 30 LBP (Age 24.53±1.61 years; Height 175.70±2.04cm; Weight 79.44±3.50kg; and Oswestry Disability Index (ODI) Score 32.93±2.36%). Participants in the LBP group were currently not experiencing an episode of LBP, so the ODI score represented what their disability was like during an episode. **Interventions:** Prior to starting the actual testing session, each participant was familiarized with the two exercises and practiced the exercises over three repetitions with clinician feedback on proper performance. For the testing session, all participants performed three trails of ADIM and quadruped exercises in a counterbalanced order while an experienced examiner recorded USI measurements of TrA thickness. For the ADIM, the participant was positioned in hook lying. For the quadruped exercise, the participants started on the hands and knees, then proceeded to extend the right arm and left leg. This position was held for five seconds before returning to the starting position. The ultrasound transducer was placed between the pelvic crest and 12th rib, along the midaxillary line of the right side. To ensure correct imaging of the muscle across participants, the right most structure was the hyperechoic interface of the TrA and thorocolumbar fascia. All images were captured at the end of exhalation. Three images were captured at rest, or the starting position, and three images were captured during contraction, or at the end of limb movement. **Main Outcome Measures:** TrA activation ratio (contracted TrA(mm)/rest TrA(mm)). Independent t-tests were used to compare TrA activation ratio between groups. **Results:** There were no significant differences between activation ratios of the two groups during the ADIM (H:1.49±.27 vs LBP:1.55±.32; p=.445) nor the quadruped exercise (H:1.35±.26 vs LBP:1.47±.38; p=.114). **Conclusions:** Both healthy and LBP patients can activate the TrA during the ADIM and quadruped exercises after brief instruction from a clinician. However, there were no differences between groups on how activated the TrA was during exercise. It is possible that clinician feedback plays a vital role in proper exercise technique. Both exercises are appropriate to activate the TrA during rehabilitation.

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**Effect Of Traditional Bridging Or Sling Bridging Exercise On Transversus Abdominis Activation Ratio In Individuals With Low Back Pain**

Guthrie RJ, Grindstaff TL, Croy T, Ingersoll CD, Saliba SA: University of Virginia, Charlottesville, VA; Emory University, Atlanta, GA; Central Michigan University, Mt. Pleasant, MI

**Context:** Previous research has found that there is a subgroup of patients with low back pain (LBP) that show improvement following a stabilization exercise intervention. The transversus abdominis (TrA) has been implicated to be an important muscle for the stabilization of the spine and is targeted for rehabilitation exercises. Recent evidence has demonstrated that the TrA is active during traditional bridging exercise. Performance of exercises on unstable surfaces is thought to increase muscle activation, however no research has investigated differences in TrA activation when performing common stabilization exercises on stable versus unstable surfaces. **Objective:** To investigate the change in TrA activation after performing a bridging exercise on a stable versus unstable surface in individuals with LBP who meet stabilization classification criteria. **Design:** Randomized Control Trial. **Setting:** Laboratory. **Participants:** Fifty-one adults (mean±SD; age= 23.1±6.0 years, height= 173.6±10.5, cm, mass= 74.7±14.5 kg, and 64.7% female) with

LBP participated in this study. All participants met 3 out of 4 criteria for stabilization classification LBP or at least 6 best fit criteria for stabilization classification. **Interventions:** Participants were randomly assigned to either a traditional bridging (stable surface) exercise progression or a sling bridge (unstable surface) exercise progression. All participants performed 4 sets of 5 repetitions and were progressed through each of the 4 levels based on subjective criteria. Both the traditional bridge and sling bridge progression were performed in a supine hook-lying position, but the sling bridge progression involved a suspended rope and sling placed distal to the knees to create an unstable surface. Ultrasound images were captured on the involved side of pain and on the right side in the event of central or bilateral pain. The ultrasound transducer was placed along the lateral abdominal wall on the midaxillary line superior to the iliac crest. Three ultrasound images were captured at rest and during ADIM. TrA activation ratio was measured pre-intervention and post-intervention and a 2x2 mixed model ANOVA was performed to compare the average TrA thickness ratio before and after exercise (traditional bridge or sling bridge). **Main Outcome Measures:** Resting and contracted TrA thickness, measured in centimeters, were used to calculate the dependent variable, TrA activation ratio (TrA contracted thickness/TrA resting thickness). **Results:** There was a significant difference ($P$= .05) when examining TrA activation ratios by group. The traditional bridge progression (Pre= 1.55±0.22; Post= 1.65±0.21) resulted in greater TrA activation following exercise than the sling bridge progression (Pre= 1.60±.31; Post= 1.55±.25). **Conclusions:** The findings of this study suggest that TrA activation ratios are higher following a traditional bridging exercise progression than after a sling bridging progression in individuals with LBP who meet stabilization classification criteria. The use of unstable surfaces did not increase TrA muscle activation following exercise intervention.

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**Clinical Assessment Of Transversus Abdominis Function In Individuals With Low Back Pain**

Grooms DR, Grindstaff TL, Croy T, Hart JM, Saliba SA: University of Virginia, Charlottesville, VA, and College of Mount St. Joseph, Cincinnati, OH

**Context:** Individuals with low back pain (LBP) have a deficit in transversus abdominis (TrA) muscle activation. A pressure biofeedback device may be used to estimate TrA activation while performing an abdominal drawing-in maneuver (ADIM), but has not been validated against ultrasound imaging. **Objective:** To assess the ability of pressure biofeedback to evaluate TrA muscle function during an ADIM in individuals who meet stabilization classification criteria. **Design:** Descriptive laboratory study. **Setting:** Laboratory. **Participants:** Fifty-one individuals with LBP who met stabilization classification criteria (mean ± SD, age 23.1 ± 6.0 years, height 173.60 ± 10.5 cm, mass 74.7 ± 14.5 kg). **Interventions:** A pressure biofeedback unit, connected to an in-line pressure transducer, was placed under the lumbar spine and inflated to 40 mmHg. Individuals performed an ADIM, in a supine hook-lying position, while changes in pressure were recorded along with simultaneous recording of muscle thickness using ultrasound imaging. Ultrasound images were captured on the involved side of pain and on the right side in the event of central or bilateral pain. The ultrasound transducer was placed along the lateral abdominal wall on the midaxillary line superior to the iliac crest. Three ultrasound images were captured at rest and during ADIM. TrA activation ratio was calculated for each image from the TrA muscle thickness at rest to the contracted thickness (TrA contracted thickness/TrA relaxed thickness). Participants were dichotomized into high (> 1.8) or low (< 1.8) TrA activation ratio groups and a Mann-Whitney U test was used to compare differences in pressure during the ADIM between the groups. Participants were also dichotomized based on the ability to adequately maintain pressure (< 5 mmHg change in pressure) while holding the ADIM for 10 seconds. Sensitivity, specificity, positive and negative predictive values and likelihood ratios were also calculated. **Main Outcome Measures:** TrA muscle thickness was measured in centimeters and pressure was measured in mmHg. **Results:** When participants were dichotomized based on TrA activation ratio, 80% had a value that was considered low (<1.8) and 20% had value that was considered high (>1.8). Pressure was not significantly different ($P$= .68) between high (42.7±5.1 mmHg) and low (42.1±2.9 mmHg) TrA activation groups. The pressure biofeedback unit had low sensitivity (.23), but high specificity (.80) with a positive predictive value of 0.82 and a negative predictive value of 0.21. Positive (1.15) and negative (.96) likelihood ratios indicated very little shift in probability. **Conclusions:** Inability to maintain pressure (positive test) during an ADIM detected poor TrA function, but the ability to maintain pressure (negative test) was unable to differentiate between high and low TrA activation. Pressure biofeedback may not be a valid tool to determine TrA activation during an ADIM performed in a supine, hook-lying position.

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# Free Communications, Thematic Poster: Fatigue & Lower Extremity Biomechanics: Implications for Injury

Friday June 25, 2010, 10:00AM-11:30AM, Room 202AB; Moderator: J. Troy Blackburn, PhD, ATC

**The Effects Of Two Fatigue Protocols On Kinematics And Kinetics During A Running-Stop Jump Task**

Quammen D, Onate JA, Cortes N, Lucci S, Van Lunen B: Old Dominion University, Norfolk, VA

**Context:** Neuromuscular control strategies and biomechanical parameters are altered when the effects of fatigue are present. Different types of fatigue have been utilized, but no study has assessed the effects of linear vs. agility fatigue protocol on lower extremity biomechanics. **Objective:** To determine neuromechanical differences between two fatigue protocols [Slow Linear Oxidative Fatigue Protocol(SLO-FP) and Functional Agility Short-Term Fatigue Protocol(FAST-FP)] when performing an unanticipated running stop-jump task(RS). **Design:** Quasi-experimental. **Setting**: Controlled Laboratory. **Participants:** Fifteen Division I female soccer players (age=19.2±0.8years; height= 1.67±0.05m; mass=61.7±8.1kg) were free of lower extremity injury at time of participation. **Interventions:** Participants performed five successful trials of a RS task pre and post fatigue protocols. The SLO-FP, a $VO_{2peak}$ test was conducted prior to the fatigue protocol. Five-minutes after the conclusion of $VO_{2peak}$ test subjects started the fatigue protocol by performing a 30-minute interval run with six intervals (four minutes at 70% of $VO_{2peak}$ speed followed by one minute at 90% of $VO_{2peak}$ speed). The FAST-FP consisted of

4 sets of a functional circuit that included: L-Drill, Ladder, Vertical Jumps, and step-ups. Separate repeated 2(time)x2(protocol) ANOVAs were conducted to assess neuromechanical differences. Alpha level set at .05. **Main Outcome Measure(s):** Independent variables were fatigue protocols (SLO-FP and FAST-SP), and time(pre and post). Dependent variables included kinematic and kinetic variables of hip flexion(HF), hip internal rotation(HIR), hip abduction(HAB), knee flexion(KF), knee abduction(KAB), knee extension moment (KEM), and knee abduction moment (KABDM), at initial contact(IC), peak stance (Max), peak knee flexion(PKF), peak vertical and posterior ground reaction forces (PVGRF and PPGRF, respectively). **Results:** During SLO-FP at IC participants had increased knee adduction internal moment (0.064±0.09Nm/Kgm) when compared with the FAST-FP (0.024± 0.06Nm/kgm),$p$=0.033. Participants had decreased HF at IC post-fatigue (44.7±8.1º) when compared with pre-fatigue (50.1±9.5º),$p$=0.001 as well as at PVGRF post-fatigue (44.7±8.4º) when compared with pre-fatigue (50.4± 10.3º),$p$=0.001; at PPGRF post-fatigue (45.2±8.6) when compared with pre-fatigue (51.1± 10.8º),$p$=0.001; at PKF post-fatigue (38.7±8.7º) when compared with pre-fatigue (45.1±11.6º),$p$=0.001, and at max HF post-fatigue (47.3±8.2º) when compared with pre-fatigue (53.3±10.95º), $p$=0.001. Participants were in significantly lower KF at PVGRF post-fatigue (-35.7±6.5º) when compared with pre-fatigue (-38.8±5.03º),$p$=0.001, at PPGRF post-fatigue (-35.6±7.2º) when compared with pre-fatigue (-38.4± 5.6º),$p$= 0.001, and at PKF post-fatigue (52.5±7.9º) when compared with pre-fatigue (56.8± 8.3º),$p$=0.001. During SLO-FP subjects had increased KEM (2.01±.32Nm/Kgm) when compared with the FAST-FP (1.9±.36Nm/ Kgm),$p$=0.033. **Conclusions:** Both protocols induced similar changes to lower extremity biomechanics. Our results demonstrated a decrease in hip and knee flexion angles at post-fatigue condition. Landing in an upright position has been shown to increase anterior tibial shear force, which augments the loads on the ACL. Future research should examine the effects of multiple unanticipated tasks during various fatigue protocols.

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**Quadriceps And Hamstrings Co-Contraction Is Not Altered Following Isokinetic Fatigue In Recreationally Active Volunteers With A History Of Knee Pain And Mild Quadriceps Inhibition**

Frye JL, Allaire P, Kerrigan DC, Saliba EN, Weltman AL, Ingersoll CD: University of Virginia, Charlottesville, VA, and James Madison University, Harrisonburg, VA

**Context:** Arthrogenic muscle inhibition is present in the quadriceps in patients reporting knee pain despite remaining physically active. It is unknown if this quadriceps inhibition alters the function of their quadriceps muscles. **Objective:** The purpose was to evaluate rectus femoris (RF) and biceps femoris (BF) electromyography following isokinetic quadriceps fatigue among volunteers with and without quadriceps muscle inhibition (MI) as measured by a central activation ratio (CAR). It was hypothesized that active volunteers reporting knee pain with measurable quadriceps MI would exhibit delayed activation of their RF and BF during a drop landing thus decreasing the subject's ability to attenuate forces during activity. **Design:** A static group comparison was used. **Setting:** This study was conducted in a research laboratory. **Patients or Other Participants:** Group one included 11 active volunteers (7 females, 4 males) without lower extremity injury and a CAR of 0.94 or above (age=27.2±7.1 yrs, height=171.6±7.1 cm, mass=72.4±18.8 kg, CAR=96.57±2.53). Group two included 13 active volunteers (8 females, 5 males) with knee pain and a CAR of 0.90 or less (age=25.2±5.4 yrs, height=173.0±11.5 cm, mass=78.2±13.3 kg, CAR=79.38±8.99). **Interventions:** The independent variables were group (non-inhibited quadriceps and inhibited quadriceps group) and state (non-fatigued and fatigued). Three averaged superimposed burst measurements were taken to measure the subjects' CAR. Subjects performed an isokinetic quadriceps fatigue protocol until quadriceps force reduced 50% from maximum voluntary contractions taken initially. Separate MANOVAs compared the RF and BF. **Main Outcome Measures:** The dependent variables were normalized root mean square (N-RMS) and normalized area under the frequency curve (N-AREA). These estimated the muscle activation at foot contact of a drop landing. **Results:** Non-inhibited pre-fatigue N-RMS for RF was 1.4±2.2 mV and post-fatigue was 2.0±2.0 mV; inhibited pre-fatigue N-RMS was 1.3±0.6 mV and post-fatigue was 1.7±1.7 mV. RF analyses revealed a main effect for N-AREA time (N-AREA: $F_{1,22}$=14.986, $P$=0.001, $\eta^2$=0.405, 1-β=0.959) although no main effect for N-RMS time (N-RMS: $F_{1,22}$=3.246, $P$=0.085, $\eta^2$=0.129, 1-β=0.406). No group by fatigue interaction for RMS analysis ($F_{1,22}$=0.11, $P$=0.74, $\eta^2$=0.005, 1-β=0.06) or AREA ($F_{1,22}$=0.33, $P$=0.57, $\eta^2$=0.01, 1-β=0.08) was found. Non-inhibited pre-fatigue N-AREA for BF was 24.3±33.03 mV-Hz and post-fatigue was 4.8±5.3 mv-Hz; inhibited pre-fatigue N-AREA was 17.7±9.1 mv-Hz and post-fatigue was 3.2±2.8 mv-Hz. No BF main effect for time (RMS=$F_{1,22}$=0.127, $P$=0.725, $\eta^2$=0.006, 1-β=0.063; AREA= $F_{1,22}$=0.015, $P$=0.904, $\eta^2$=0.001, 1-β=0.052) or group (RMS=$F_{1,22}$=1.471, $P$=0.238, $\eta^2$=0.063, 1-β=0.213; AREA= $F_{1,22}$=0.153, $P$=0.7, $\eta^2$=0.007, 1-β=0.066) or group by fatigue interaction for RMS ($F_{1,22}$=2.78, $P$=0.11, $\eta^2$=0.11, 1-β=0.36) or AREA ($F_{1,22}$=0.33, $P$=0.57, $\eta^2$=0.15, 1-β=0.86) was found. **Conclusions:** Inhibited subjects had similar muscle activity as non-inhibited subjects following isokinetic fatigue during drop landings. Further work should evaluate the muscle activity timing following general body fatigue in subjects with quadriceps MI.

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**The Effect Of Muscle Fatigue On Valgus Knee Kinematics**

Ransone JW, Wedding HA, Guerrero JM, Vela LI, Pankey RB: Texas State University, San Marcos, TX

**Context**: Incidence risk of knee injury in female athletes is statistically higher incidence than their male counter-parts. Neuromuscular deficits, knee valgus movement and muscular strength deficits are proposed reasons for increased risk of injury. **Objective:** The purpose of this investigation was to determine the effect of dynamic knee valgus movement during a single leg squat before and after a quadriceps and hamstring fatigue protocol in physically active females. **Design:** Repeated measures design**. Setting:** Controlled laboratory setting. **Patients or Other Participants:** Thirty-one physically active females (21±2.13 yrs, 61.02±7.33 kg, 167.34±6.08 cm) with no previous history or current lower extremity injury or previous history, which would interfere with ability to perform single leg squat volunteered to participate in this investigation. **Interventions:** All subjects completed two single leg squats of dominate leg from a box (height specified and adjusted according to leg length) to approximately 70 degrees of knee flexion and averaged before and after an isokinetic knee strength testing and the fatigue protocol. Reflective markers were placed on the anterior superior iliac spine, mid-patella, tibial tuberoscity and the lateral malleolus to assess valgus knee dynamic motion. Frontal plane

knee angle motion was evaluated with a Dartfish Motion Analysis System filmed at 250Hz using two 2-D SportsCam High Speed Camera situated perpendicular to the frontal plane. Isokinetic (60 deg/sec) concentric knee (flexion/extension) strength was measured and followed by an immediate isokinetic (60 deg/sec) concentric knee fatigue protocol with a BioDex 4 Isokinetic Dynamometer. Fatigue was established when peak torque values for hamstrings and quadriceps muscles fell below 50% of the previously recorded subject knee peak torque. **Main Outcomes:** The dependent variable was knee valgus knee angle while standing and at peak during three single leg squats to 70 degrees of flexion prior to and following a lower leg fatigue protocol measured by high speed cameras. **Results:** All subjects completed both sessions. Significant differences ($F_{2,30}$=20.17, p<0.001) existed between standing (5.12±2.56 degrees) and peak knee angle before fatigue protocol (10.43±6.15 degrees) and following fatigue protocol (9.89±5.62 degrees). There was no significant main effect (p>0.05) in peak valgus knee angle for both dependent variables. Effect size for the difference between pre and post fatigue dynamic knee valgus motion was 0.046 (d = -0.092, 95% CI -1.635 to 2.715). **Conclusions:** Significantly different mean knee valgus angles existed in the frontal plane between standing and peak knee valgus movement. However, fatigue of hamstring and quadriceps musculature does not significantly change knee valgus kinematics in physically active females. Future work is needed to determine the increased incidence of female lower leg injuries as compared to male counterparts.

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**The Influence Of Ankle Bracing And Fatigue On Ankle Stability In Subjects With Chronic Ankle Instability**

Gribble PA, Cattoni SL, Bieringer M: University of Toledo, Toledo, OH

**Context:** Braces are implemented to provide ankle stability during physical activity. There is limited information to know if braces provide adequate support for those with and without chronic ankle instability (CAI), and if the proposed provided mechanical stability is diminished during high intensity activity. **Objective:** To measure ankle stability with and without an ankle brace before and after a functional fatigue task in subjects with and without CAI. **Design:** Cross over, cohort design. **Setting:** Research Laboratory. **Patients or Other Participants:** Six subjects with unilateral CAI (age:21.50±1.38yrs; height:166.37±9.19cm, mass:68.42±10.96kg) and six Control subjects (age:21.83±2.71yrs; height:169.34±6.93cm, mass:63.50±8.84kg) volunteered to participate. **Interventions:** Ankle mechanical stability was assessed with and without a lace-up style ankle brace (applied by an ATC), before and after a functional fatigue protocol. An ankle arthrometer was used to measure stability of the injured limb of the CAI group and a matched limb of the Control subjects. Prior to the fatigue task, ankle stability was quantified in barefoot and braced ankle conditions. The functional fatigue circuit, a series of sprints, side shuffles, lunges and vertical jumps, was repeated until the time circuit completion time increased by 50% of the baseline time. This protocol was performed while wearing the ankle brace. Immediately after achieving the designated level of fatigue, ankle stability assessments were repeated. **Main Outcome Measures**: To assess ankle stability, anterior/posterior (A/P) loading was performed first followed by inversion/eversion (I/E) loading. Three trials were completed in each direction on each ankle, with the average total A/P (mm) and total I/E (degrees) excursions used as two dependant variables. For each dependant variable, a Time (Pre-fatigue, Post-fatigue) by Condition (Brace, No-Brace) by Group (CAI, Control) repeated measures ANOVA was performed. Statistical significance was set *a priori* at P<.05. **Results:** For total A/P stability, a significant main effect for brace was observed ($F_{1,10}$=10.86; P=0.008). The brace provided more A/P stability (11.90±3.87mm) than the no-brace condition (14.42±3.20mm), which was associated with an effect size of 0.71. For the I/E stability measures, a significant main effect for brace was observed ($F_{1,10}$=320.71; P<.001). The brace provided more I/E stability (23.92±7.68degrees) than the no-brace condition (50.58±11.02degrees), which was associated with an effect size of 2.81. There were no interaction influences of Time or Group on A/P or I/E stability. **Conclusions:** Both CAI and Control subjects had significantly more A/P and I/E mechanical stability after the application of an ankle brace. This increased stability did not diminish after participation in a functional fatigue protocol. It appears that a lace-up ankle brace is able to provide immediate and consistent stability following participation in intense athletic activity equally well for individuals with and without CAI.

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**Under Recovery And Pre-Season Drop Jump Characteristics In Female Collegiate Basketball Players**

Zody AR, Rossi SJ, McMillan JL, Buckley TA: Georgia Southern University, Statesboro, GA

**Context**: With collegiate athletes extensive pre-season training can sometimes lead to under recovery, potentially resulting in poor performance, injury, or illness. To minimize these risks and promote optimal seasonal performance, athletes must maintain a fine balance during pre-season training. **Objective:** The purpose of this study was to examine the pre-season recovery of female basketball players using drop jump characteristics and recovery stress state (RESTQ-Sport 76). **Design:** Prospective repeated measures design. **Setting:** Human Performance and Biomechanics laboratories. **Participants:** Participants were 14 NCAA Division 1 female basketball players (age= 19.29 ± 1.54 years, mass= 746.19 ± 146.03 kg, height= 178.71 ± 6.27 cm). **Interventions:** The REST-Q Sport 76 questionnaire has high internal consistency (Cronbach = 0.85) for assessing self-perceived stress and recovery. Drop jump was performed from a height of 30cm onto two 400x600mm forceplates (Model OR-6, AMTI, Watertown, MA) and data was sampled at 1000 Hz. Participants were assessed on three occasions ($T_1$, $T_2$, $T_3$) over the month of the preseason with approximately two weeks between each test date. **Main outcome measures:** Drop jump performance measures of reactive strength index (RSI) (jump height /contact time), flight time (FT), and jump height (JH) were compared across all three time periods with a repeated measures ANOVA with post-hoc for time differences. REST-Q total recovery stress score, global recovery score, and global stress score were compared between $T_1$ and $T_3$ using a paired sample T-test. **Results:** Repeated measures ANOVA showed significant differences from $T_1$ to $T_3$ in all three performance variables: RSI (.651 ± .25 and .607 ± .20 respectively, p= 0.031), FT (.453 ± 0.03s and .436 ± 0.04s respectively, p=0.016) and JH (25.4 ± 0.3cm and 23.3 ± 0.4cm respectively, p=0.007). Although not significant, we did find trends in an expected direction for relative peak force, (4.523± .74 xBW and 3.988 ±.55 xBW, p = .055). We found no significant differences from $T_1$ to $T_3$ in REST-Q scores, (p > .05). **Conclusions:** These results show drop jump characteristics declined over the course of pre-season training. Although we did not find significant increases in REST-Q scores, this may be because perceived stress was abnormally high at $T_1$. This data supports the recommendation that both a performance and psychological test may be necessary to provide accurate information regarding recovery of female collegiate athletes during pre-season training.

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**The Effects Of Isolated Knee Flexion Fatigue On Jump Landing In Healthy Recreational Athletes**

Phillips K, Onate JA, Cortes N, Ringleb S, Etnoyer JE, Van Lunen B: Old Dominion University, Norfolk, VA

**Context:** Injury to the anterior cruciate ligament (ACL) remains a traumatic injury in athletics and recreational activities with higher incidence occurring in the female population. Neuromuscular fatigue has been linked to altered neuromechanics during jump landing tasks. A decrease in neuromuscular performance can markedly increase risk of injury because the protective capabilities of the musculature surrounding the knee are compromised. **Objective:** To analyze the effect of knee flexor fatigue on knee and hip kinematics while landing from a box-drop jump. **Design:** Quasi-experimental design. **Setting**: Controlled Laboratory. **Participants:** Fourteen healthy female recreational athletes (age=21.4±1.45 yrs; height=165.1±8.3 cm; mass=65.6±16.4 kg) with no history of an ACL or lower extremity injury or surgery in the past two months volunteered to participate in the current study. **Interventions:** Kinematic data were collected during 5 trials of a box-drop jump pre and post fatigue with an eight-camera high-speed system sampled at 500Hz (VICON Motion System). The fatigue protocol consisted of isokinetic eccentric knee flexor motion at 120°/second with 90° of range of motion was applied using the Primus RS (BTE Technologies Inc). Prior to the fatigue protocol, five eccentric repetitions were conducted to determine peak torque (Nm). A 30% eccentric isokinetic knee-flexor torque reduction was set as the criteria for ceasing the protocol indicating muscle fatigue. **Main Outcome Measure(s):** Hip and knee flexion, and knee valgus were measured pre and post fatigue at time of initial contact, at maximum knee flexion, and maximum hip flexion during the stop-jump phase of a box-drop jump. Paired *t*-tests were conducted for each of the dependent variables. A significance level of $p<0.05$ was set *a priori* for all analyses. **Results:** At initial contact, hip flexion significantly increased post-fatigue (43.8±8.2,CI=39.0;48.5) than pre-fatigue (40.7±6.8,CI=36.7;44.6)($t$=-2.56, $p$=.023). No other statistically significant differences were found at either the hip or knee at initial contact or maximum knee or hip flexion. **Conclusions:** Our results demonstrated that fatigue of the knee flexors altered hip flexion at initial contact. Although fatigue adversely affects the neuromuscular function, altered kinematics of the lower extremity during tasks may be highly dependent upon the fatigue task and protocol chosen. Subjects may have placed greater reliance on non-fatigued musculature (i.e., knee extensors and hip abductors) in the lower extremity to adapt to the neuromuscular demands of the box-drop jump. It is important to analyze the effects of fatigue to various muscle groups, as the body's subsequent movement patterns are likely to change. Similarly, different jump landing tasks are of interest to replicate different demands seen in athletics.

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**The Influence Of Ankle Bracing And Fatigue On Time To Stabilization In Subjects With Chronic Ankle Instability**

Cattoni SL, Pasquale TR, Pietrosimone BG, Gribble PA: University of Toledo, Toledo, OH

**Context:** Athletes commonly use ankle prophylactic devices to increase stability and help prevent injury. Fatigue is experienced frequently during athletic participation and may create decreases in dynamic stability, potentially exacerbating ankle instability. It is unknown whether the application of an ankle brace can increase dynamic stability to overcome the effects of fatigue in those individuals with chronic ankle instability (CAI). **Objective:** To determine the effects of ankle bracing and fatigue on dynamic stability in patients with CAI and healthy controls. **Design:** Repeated measures, cohort design. **Setting:** Research Laboratory. **Patients or Other Participants:** Six subjects with unilateral CAI (5 F/1 M; age:21.50 ±1.38yrs; height:166.37±9.19cm, mass:68.42± 10.96kg) and six Control subjects (6 F; age:21.83 ±2.71yrs; height:169.34 ±6.93cm, mass:63.50 ±8.84kg) volunteered to participate. **Interventions:** Dynamic stability was assessed in the injured limb of the CAI subjects and matched limb of the control group, before and after a functional fatigue protocol, using Time to Stabilization (TTS) measured during a single-leg jump-landing at 50% of the subjects' maximum vertical jump height. The functional fatigue circuit, a series of sprints, side shuffles, lunges and vertical jumps, was repeated until the time it took to complete the circuit increased to 50% of the baseline time. Immediately after fatigue was reached, the single-leg jump-landing measures were repeated. This protocol was performed with and without an ankle brace on 2 separate days, in a counterbalanced order. **Main Outcome Measures**: TTS values in the anterior/posterior (APTTS) and medial/lateral (MLTTS) directions were calculated from A/P and M/L ground reaction force data. Three trials were completed before and after fatigue, with and without an ankle brace. The average A/P and M/L TTS values were used as dependent variables. For each of these two dependant variables, a separate 2-within (Condition, Time), 1-between (Group) repeated measures ANOVA was performed. In the event of statistically significant interactions, a Tukey's post-hoc test was applied. Statistical significance was set *a priori* at $p\leq.05$. **Results:** For MLTTS, a significant Brace by Group interaction was observed ($F_{1,10}$= 4.95; p=.05). In those with CAI, the brace provided more M/L dynamic stability (1.709±0.114 sec) than the no-brace condition (1.802±0.156 sec). In the brace (Control:1.619±0.066 sec; CAI:1.709± 0.114sec) and no-brace (Control:1.597±0.053; CAI:1.802±0.156 sec) conditions, CAI subjects took longer than Control subjects to stabilize. There were no significant influences on APTTS. **Conclusions:** Subjects with CAI took significantly longer to stabilize in the M/L direction than their healthy counterparts with and without a brace. Also, the application of an ankle brace was found to provide CAI subjects with significantly more dynamic stability in the M/L direction, suggesting that the use of an ankle brace can improve dynamic stabilization during landing in individuals with CAI, which may decrease the risk of injury. Fatigue did not amplify these differences.

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**Lower Extremity Neuromuscular Control Immediately Following Fatiguing Hip Abduction Exercise**

McMullen KL, Cosby NL, Ingersoll CD, Hertel J, Hart JM: University of Virginia, Charlottesville, VA

**Context**: The role of hip abduction and external rotation strength has in core stability is important in the prevention of lower extremity injuries. Fatigue of the gluteus medius (GMed) may be associated with a decrease in postural control due to insufficient pelvic stabilization. Males and females may have varying muscular recruitment patterns in response to GMed fatigue. Differing responses in males and females may help explain higher rates of knee injuries in females **Objective**: To determine the effects of GMed fatigue following an eccentric side-lying hip abduction exercise on static and dynamic balance, and core stability between males and females. **Design**: Descriptive laboratory study. **Setting**: Laboratory. **Participants**: Eighteen male (age 22 ± 3.6 years, height 183.4 ± 8.3 cm, weight 87.0 ± 12.53 kg) and 18 female (age 22 ± 3.1, height 167.7 ± 5.8 cm, weight 66.6 ± 10.5 kg) participants with no history of low back or lower extremity injury participated in this study. **Interventions**: The intervention consisted of a fatiguing protocol that involved a side-lying eccentric hip abduction exercise. Subjects performed the hip abduction exercise until a 15% shift in EMG median frequency was

reached. **Main Outcome Measures**: Static dominant limb balance was assessed using center of pressure (COP) velocity, COP area, standard deviation (SD) medial lateral (x) and SD anterior posterior (y). The star excursion balance test (SEBT) was used to measure normalized reach distance in 3 directions: anterior, posteromedial, and posterolateral. The lateral step down test (LSDT) was graded on a 6-point scale as a measure of core stability. **Results**: There were no significant differences in the observed balance deficits following fatigue between genders (p=.78). Significant main time effects were observed with all outcome measures post-fatigue. Increased frequency of postural corrections (COP velocity pre=3.6±0.2, COP velocity post=4.4±0.4, p= .039), increased excursion area (COP area=6.2±0.4, COP area=8.7±0.8, p= .001), and more variability in frontal (SDx pre=.5±0.02, SDx post=0.5±0.02, p < .001) and sagittal (SDy pre=0.70±0.03, SDy post=0.8±0.1 p= .008) planes were observed following a hip abduction fatiguing exercise. SEBT reach distances decreased (anterior pre=68.3±0.9cm, anterior post=62.7±0.9 cm, p<.001; posteromedial pre=82.4±1.6 cm, posteromedial post=76.5±1.6 cm, p<.001; posterolateral pre=78.6±1.9 cm, posterolateral post=72.6±1.9 cm, p<.001) and scores on the lateral step down test increased (LSDT pre=2.2±0.1, LSDT post=2.9±0.1, p<.001) following fatigue. **Conclusions**: Postural control and core stability were negatively affected by GMed fatigue after a eccentric hip abduction exercise. When taken to the same rate of metabolic fatigue, there was no difference between genders on measurements of lower extremity neuromuscular control.

# Free Communications, Oral Presentations: Shoulder & Overhead Athlete

Friday, June 25, 2010, 11:45AM-12:45PM, Room 202AB; Moderator: Joe Meyers, PhD, ATC

### The Relationship Between Pitch Volume And Innings Pitched In Southeastern Conference Baseball Pitchers

Love SD, Uhl TL, Bush HM, Aytar A: Division of Athletic Training, University of Kentucky, Lexington, KY, and Department of Physical Therapy and Rehabilitation, Baskent University, Ankara, Turkey

**Context:** Pitch volume for adolescent pitchers has been described in detail and has been found to be a contributor to injury risk. There is a lack of information describing typical pitch volume in collegiate baseball pitchers. **Objective:** To describe and compare game pitch volume for collegiate baseball pitchers in the Southeastern Conference. **Design:** Descriptive cohort study design. **Setting:** Web based data collection. **Patients or Other Participants:** One hundred and eighty-five division one collegiate baseball pitchers from the Southeastern Conference. **Interventions:** Data were collected by accessing each team's athletic website and recording the number of pitches and innings pitched for each player from the post-game box score for 2009 season. Games were recorded and categorized based on the opponent played as: conference, non-conference, and tournament games. Later in data reduction pitcher types were identified based on their role as "Starter-only", "Reliever-only", or "Combo" which meant the pitcher had at least one role as both starter and reliever in two different games. "Combo" category was further sub-divided based on the player's role for a game termed "Combo-starter" or "Combo-reliever". **Main Outcome Measures:** Dependent variables included average number of pitches per game and a cumulative total number of pitches for the entire season for each pitcher. Comparisons of pitch volume by pitcher category and between game types were determined using ANOVA. A Bonferroni post-hoc analysis was performed when appropriate. An *a priori* significance was set at p<.05 for all analysis. **Results:** Descriptive statistics per appearance revealed that "Starter-only" pitchers (n=15) threw 97±10 pitches, "Combo-starter" pitchers (n=94) threw 68±19 pitches, "Combo-reliever" pitchers (n=94) threw 29±14 pitches, and "Reliever only" pitchers (n=75) threw 23±7 pitches. "Combo-starter" pitchers threw significantly more pitches in tournament games (87±23) compared to non-conference games (66±18) (P<.001). "Starter-only" pitchers threw significantly more pitches in conference games (102±13) compared to non-conference games (82±16) (P=.007). On average, "Starter-only" pitchers (1204±340) threw significantly more total pitches over the entire season compared to "Combo" pitchers (613±366) who threw significantly more than "Reliever only" pitchers (254±224) (P<.001). **Conclusions:** Collegiate pitcher roles determine their throwing volume and should be taken into consideration during the development of throwing programs for collegiate pitchers in the off-season and in return to throwing programs following an injury. The program should be structured to meet the specific demands of the collegiate pitcher's role. These results indicate pitch volumes vary through out season for starting pitchers in particular, based on the level of play. The increased pitch volume (~24%) for the "Combo" pitchers participating as starters during tournament competition should be taken into consideration to allow for adequate rest. We acknowledge these data underestimate total volume of pitching as no warm-up or practice pitches were not collected.

### The Relationship Between Latissimus Dorsi Stiffness And Altered Scapular Kinematics Among Collegiate Swimmers

Laudner KG, Williams JG: Illinois State University, Normal, IL

**Context:** Due to the large number of shoulder revolutions performed by swimmers during practices and competitions, it is not surprising that most swimmers report shoulder pain at some time during their swimming career. Furthermore, scapular dyskinesis has been attributed to the development of such injuries. Due to the excessive activity of the latissimus dorsi during the swim stroke competitive swimmers may present with latissimus dorsi stiffness. Based on these past findings and the attachment of the latissimus dorsi to the scapula, stiffness of this muscle may be associated with scaplular dyskinesis. **Objective:** To determine the strength of the relationship between latissimus dorsi stiffness and scapular kinematics among swimmers. **Design:** Descriptive statistics. **Setting:** University athletic training room. **Patients or Other Participants:** Nineteen NCAA Division III swimmers (7 male and 12 female) (age = 18.8±0.9 years, height = 174.7±8.9 cm, mass = 71.6±11.9 kg) volunteered to participate. Subjects had no recent history (past 2 years) of upper extremity pathology or any previous surgery. **Interventions:** We measured latissimus dorsi stiffness of the dominant arm while in a lengthened position with a myotonometer (Neurogenic Technologies Inc., Missoula, MT). We used an electromagnetic tracking device (Polhemus, Colchester, VT) with specialized software (Motion Monitor, IST) to measure scapular kinematics at humeral elevation angles of 30°, 60°, 90°, and 110° within the scapular plane. We used Pearson Product Moment Correlation Coefficients (*r*) to determine if relationships existed between

the aforementioned variables ($P < 0.05$). **Main Outcome Measures:** Latissimus dorsi stiffness (independent variable) and scapular upward/downward rotation, internal/external rotation, and anterior/posterior tilt (dependent variables). **Results:** The mean and standard deviation for latissimus dorsi stiffness was 8.3±2.3 mm. At humeral elevation angles of 30°, 60°, 90°, and 110° the means and standard of deviations for scapular upward/downward rotation were 2.2±18.8°, 9.2± 18.9°, 19.1±17.7°, and 23.5±17.1°, scapular internal/external rotation were 1.8±26.1°, 3.3±27.3°, 1.1±29.4°, -3.3±31.2°, and scapular posterior/anterior tilt were -16.0±19.4°, -8.0±21.4°, 1.5± 25.2°, 11.2±30.5°, respectively. Latissimus dorsi stiffness showed moderate-to-good relationships with decreased scapular upward rotation ($r$>-0.63, $P$<0.002) and posterior tilt ($r$>-0.62, $P$<0.004) at all four angles of humeral elevation. Increased latissimus dorsi stiffness also showed moderate-to-good relationships with decreased scapular internal rotation at humeral elevation angles of 60° ($r$=0.47, $P$=0.03) and 90° ($r$=0.54, $P$=0.01). Only scapular internal rotation at 30° ($r$=0.18, $P$=0.24) and 110° ($r$=0.28, $P$=0.13) of humeral elevation showed little-to-no relationship with latissimus dorsi stiffness. **Conclusions:** Our results suggest there are several moderate-to-good relationships between increased latissimus dorsi stiffness in swimmers and decreased scapular upward rotation, internal rotation, and posterior tilt at various angles of humeral elevation. If latissimus dorsi stiffness is not addressed subsequent scapular alterations, which have been associated with shoulder dysfunction, may occur.

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### Changes In Infraspinatus Cross-Sectional Area And Shoulder Range Of Motion With Eccentric Shoulder External Rotator Fatigue: Application To Thrower's Shoulder

Oyama S, Myers JB, Coleman E, Blackburn JT: Department of Exercise and Sport Science, University of North Carolina at Chapel Hill, Chapel Hill, NC

**Context:** The infraspinatus eccentrically resists joint distraction and humeral internal rotation (IR) and horizontal adduction (HAD) during overhead throwing. Repetitive eccentric loading results in muscle fiber damage and influx of inflammatory agents and fluid to the muscle. This fluid influx increases muscle cross-sectional area (CSA) and thereby increases muscle stiffness and decreases range of motion (ROM). Therefore, changes in infraspinatus CSA following repetitive eccentric loading during pitching may contribute to shoulder dysfunction. **Objective:** To evaluate changes in infraspinatus CSA and shoulder ROM before, immediately after, and 24 hours after eccentric external rotator fatiguing exercise. **Design:** Repeated-measures design. **Setting:** Research laboratory. **Patients or Other Participants:** Twenty physically active volunteers (13males/7females, age=23.1 ±4.3years, height=175.1±11.2cm, mass=74.1 ±14.9kg). **Interventions:** Infraspinatus CSA and shoulder external rotation (ER), IR, and HAD ROM were measured before (baseline), immediately after, and 24 hours after a fatigue protocol consisting of 9 sets of 25 repetitions of eccentric shoulder external rotation. The exercise was performed at 90°/sec on an isokinetic dynamometer with the humerus elevated to 45° in a scapular plane. All measurements and the exercise were performed on participants' dominant shoulders. **Main Outcome Measures:** Infraspinatus CSA was measured using a diagnostic ultrasound at a standardized location identified using palpable anatomical landmarks. The outline of the muscle was traced using image-processing software to calculate the CSA ($cm^2$) for each image. Three sets of images were captured for each session, and the average CSA from the constructed images were used for analyses. Shoulder ROM values were measured using a digital inclinometer, and three trial averages were calculated. Repeated measures ANOVA followed by Bonferroni post hoc analyses were used to assess changes in infraspinatus CSA and ROM. **Results:** Infraspinatus CSA significantly increased from baseline immediately after fatigue (mean diff=1.8±1.5$cm^2$, p<.001), and remained elevated from baseline at the 24-hour follow up (mean diff=1.8±1.7$cm^2$, p<.001). Shoulder IR and HAD ROM did not change significantly between baseline and post-fatigue (IR: mean diff=-1.4±6.1°, p=.348, HAD: mean diff=-1.5±3.1°, p=0.061), but were significantly decreased at the 24-hour follow up with respect to baseline (IR: mean diff=-6.8±6.4°, p<0.001, HAD: mean diff= -3.4±3.3°, p<0.001) and the immediate post-fatigue values (IR: mean diff =-5.4±8.1°, p=.012, HAD: mean diff=-1.9±3.0°, p=0.016). There were no changes in ER ROM with fatigue (p=0.279). **Conclusions:** Infraspinatus CSA remained elevated and IR and HAD ROM limited 24 hours after the eccentric exercise. While the stress experienced by the infraspinatus during the eccentric exercise is different from what experienced with prolonged pitching, it is speculated that similar changes occur at the shoulder following pitching. Therefore, measurement of infraspinatus CSA and ROM in thrower's shoulders may be used to assess the course of muscle recovery following pitching.

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### Comparison Of Standing Single Arm Shot Put Performance Between Limbs With Different Loads In Collegiate Baseball Players

Limbaugh, GK, Riemann, BL, Davies, GJ: Armstrong Atlantic State University, Savannah, GA

**Context:** Limited upper extremity (UE) functional performance tests (FPT) exist. FPT involving skill is complicated by UE dominance. Single arm shot put (SASP) tests have demonstrated promise, however more understanding is needed. **Objective:** To determine the effect of UE dominance and load on SASP performance and selected underlying kinematics. **Design:** Repeated measures. **Setting:** Controlled, laboratory setting. **Patients or Other Participants:** Twenty-two collegiate-level baseball players (20.6±1.4yrs; 181.3±6.1cm; 86.4±10.0kg) without recent UE injury (<1yr). **Interventions:** Dominant (DOM) and non-dominant (NDOM) SASP trials (counterbalanced between-subjects) were performed using three medicine ball (MB) masses (2kg, 3kg, 4kg). Instruction was given to hold MB at shoulder level with feet shoulder width apart and knees straight, and to press the MB for maximal distance without countermovement. Markers placed at the impact site of each trial determined horizontal range (HR). An electromagnetic system captured hand and thorax kinematics (Motion Monitor, IST, Inc) while a synchronized custom trigger indicated ball release (BR). Statistical analyses included separate two factor (limb by load) repeated measures analysis of variance ($\alpha$<.05). **Main Outcome Measures:** Release height (RH), body height normalized (%BH) was defined as the vertical hand position at BR. Hand relative to thorax vertical, anterior, and lateral displacement (VD, AD, LD) and velocity (VV, AV, LV) were determined. From these, displacement at BR, normalized to arm length (%AL), and peak velocity, were averaged across three trials. **Results:** For each load, DOM HR (2kg=6.7±.70m, 3kg=5.8±.62m, 4kg= 5.2±.53m) was significantly greater ($P$<.001) than NDOM (2kg=5.9±.55m, 3kg=5.2±.52m, 4kg=4.7±.47m), with 2kg DOM-NDOM difference significantly greater ($P$=.006, 95%$CI_{diff}$=.135–.547m) than 4kg. DOM RH (104.1±3.5%BH) was significantly higher ($P$=.019) than NDOM (102.2±3.2%BH). At BR, DOM was significantly more vertical ($P$=.008, 95%$CI_{diff}$=1.4–8.4%AL) than NDOM. For 3kg ($P$=.038, 95%$CI_{diff}$=0.6–17.2%AL) and 4kg ($P$=.008, 95%$CI_{diff}$=3.7–22.0%AL), DOM was significantly more anterior than NDOM at BR. Additionally, at BR, NDOM 2kg was significantly more anterior than 4kg ($P$=.012, 95%$CI_{diff}$=1.1–10.2%AL). At BR, DOM 4kg was significantly more lateral than 2kg ($P$=.007, 95%$CI_{diff}$=1.3–7.3%AL) and 3kg ($P$=.007, 95%$CI_{diff}$=1.8–10.1%AL). For both peak VV ($P$<.001,

95%$CI_{diff}$=0.2–0.7m/s) and AV (*P*=.001, 95%$CI_{diff}$=0.3–1.0m/s), DOM was significantly faster than NDOM. Specifically VV, the 2kg was significantly faster than 4kg (*P*<.001, 95%$CI_{diff}$=0.2–0.5m/s) and for AV, 2kg was significantly faster than 3kg (*P*=.001, 95%$CI_{diff}$=0.2–0.7m/s) and 4kg (*P*<.001, 95%$CI_{diff}$=0.4–0.9m/s). Peak LV NDOM was significantly faster (*P*=.017, 95%$CI_{diff}$=0.1–1.3m/s) than DOM. **Conclusion:** The combination of greater DOM RH, AD, AV, VD and VV coupled with greater NDOM LV and LD, likely explains the DOM-NDOM HR difference. LD and LV do not directly contribute to HR, therefore greater NDOM values may represent compensatory actions. Because unilateral athletes were assessed, further research is needed to understand if these DOM-NDOM differences are skill and/or strength/power related.

# Free Communications, Oral Presentations: Lower Extremity Injury Prevention

Friday, June 25, 2010, 1:00PM-2:15PM, Room 202AB; Moderator: James Onate, PhD, ATC

### Influence Of An Inclined Foot Position On Double Leg Squat Mechanics

Riemann BL, Ferster L, Gustavson A, Davies GJ: Armstrong Atlantic State University, Savannah, GA

**Context:** Completing declined foot position squats appears to increase knee extensor mechanical loading. Inclined (INC) foot position squats may prompt similar ankle extensor effects, which would be particularly relevant for eccentric loading approaches to Achilles tendinopathy. **Objective:** To compare double leg squat mechanics between INC and horizontal (HOZ) foot positions. **Design:** Repeated measures design. **Setting:** Controlled, laboratory setting. **Patients or Other Participants:** Thirty-one healthy, physically active (Tegner score>5) collegiate-aged men (20.7±1.9yrs, 1.75±0.05m, 83.63±1.1kg) without lower extremity injury history that could affect squat performance. **Interventions:** During a single session, participants completed four sets of six double leg squat repetitions using HOZ and INC (forefeet elevated 3.8cm) foot positions under two weight conditions, 100% body weight (100BW) and 125% body weight (125BW), in a between-subjects counterbalanced order. Instructions included completing squat repetition (2s count) to a comfortable depth. Feet were positioned over separate forceplates while an electromagnetic system (Motion Monitor, IST, Inc.) collected dominant foot, shank, thigh, pelvis and trunk kinematic data. 125BW was achieved by having subjects hold dumbbells weighted to 25% body mass. Dependent variables were calculated and averaged from four selected trials. **Main Outcome Measures:** Three summary variables, repetition time (RT), percent cycle descent-ascent transition (PC) and vertical total body center of mass displacement (vTBCM) were subjected to separate foot position by weight repeated measures analysis of variance (RMANOVA). Ankle (AN), knee (KN) and hip (HI) peak flexion (PF), and eccentric work (ECCW) were to subjected foot position by weight by joint RMANOVA. **Results:** No significant RT (*P*=.720, 1.72±.31s) or PC (*P*=.583, 56.4±4.4%) differences were revealed. HOZ (38.0±6.0cm) vTBCM was significantly greater (*P*<.001, 95%$CI_{diff}$=5.3–7.3cm) than INC (31.6±6.3cm). 125BW (35.5±.5.8cm) vTBCM was significantly greater (*P*<.001, 95%$CI_{diff}$=0.8–2.1cm) than 100BW (34.1±6.0cm). INC AN PF (-23.3±5.6°) was significantly greater (*P*<.001, 95%$CI_{diff}$=1.1–3.1°) than HOZ AN PF (-21.2±6.6°), whereas HOZ KN PF (-95.2 ±12.5°) was significantly greater (*P*<.001, 95%$CI_{diff}$=20.1–26.1°) than INC KN PF (-72.1±15.8°). HOZ (-112.9±13.2°) and INC (-113.9±13.9°) HI PF were statistically equal (*P*=.245, 95% $CI_{diff}$=.73–2.7°). For 100BW (*P*<.001, 95% $CI_{diff}$=.03–.05J/kg) and 125BW (*P*<.001, 95%$CI_{diff}$=.03–.07J/kg), the HOZ AN ECCW was significantly greater than INC AN ECCW. Similarly for 100BW (*P*<.001, 95%$CI_{diff}$ =.33–.43J/kg) and 125BW (*P*<.001, 95%$CI_{diff}$=.42–.56J/kg), HOZ KN ECCW was significantly greater than INC KN ECCW. For 125BW HI ECCW, INC was significantly greater (*P*<.001, 95%$CI_{diff}$=.12–.24J/kg) than HOZ. **Conclusions:** Although AN PF was greater, contrary to our hypothesis ECCW was less during INC compared to HOZ. During the INC weighted squats, the HI ECCW compensated for decreased AN and KN ECCW. This might suggest stress-shielding of the AN extensors by the HI while allowing exercise through larger muscle-tendon lengths. Further research is needed to verify this thesis as well as examine tendinopathy patients.

### The Effects Of Augmented Feedback On The Landing Biomechanics Of Youth Female Soccer Players

Stephenson LJ, DiStefano LJ, Blackburn JT, Bell DR, Padua DA: Ohio University, Athens, OH; The University of Connecticut, Storrs, CT; University of North Carolina at Chapel Hill, Sports Medicine Research Laboratory, Chapel Hill, NC

**Context:** Landing biomechanics are associated with increased risk for ACL injury. By intervening prior to puberty in females it may be possible to address biomechanical risk factors prior to when they become most prominent and reduce ACL injury rates. Augmented feedback is a simple intervention that has shown promise changing biomechanics in adults, but thus far has not been studied in a pediatric population. **Objective:** To determine the effects of augmented feedback on knee kinetics and kinematics in youth female soccer players during a jump-landing task. **Design:** Randomized controlled trial. **Setting:** Research laboratory. **Participants:** Twenty–seven healthy female soccer players (age=10±1 years, height=141.02 ± 6.72 cm, weight =33.55±5.28 kg) from an area soccer league's under-11 age division. **Interventions:** Subjects were randomly assigned to either a control (CON) or feedback (FB) intervention group. An electromagnetic motion analysis system interfaced with a non-conductive force plate collected lower extremity kinematics and kinetics data during a jump landing task. Two sets of three trials of the task were performed during a single testing session. The jump landing task required subjects to jump forward from a 30cm high box placed at a distance of half their height away from the force plate, land with their dominant foot on the force plate, and immediately jump for maximal vertical height. The FB group was provided with augmented feedback regarding proper landing technique prior to each trial of the second set of jump landings. The CON group received one minute of rest between each trial of the second set of jump landings. **Main Outcome Measures:** Dependent variables included sagittal and frontal plane knee angles at initial contact, peak over stance phase, and displacement, as well as peak kinetic variables during the stance phase. Stance phase was the time when the vertical ground reaction force (VGRF) was greater than 10N. The kinetic variables included VGRF, anterior tibial shear force (ATSF), knee extension moment, and knee valgus moment. VGRF and the knee kinetic data were normalized to bodyweight and the product of height and weight, respectively. Separate 2x2 (group x time) mixed model analyses of variance were performed for all dependent variables ($\alpha \leq .05$). A Tukey post hoc test was performed for significant results. **Results:** The FB group significantly decreased VGRF between pre (3.27±0.63) and post-test (2.29±0.44) and demonstrated significantly less

VGRF at post-test compared to the CON (3.19±0.71)($F_{(1,24)}$=8.497, $P$<0.01). The FB group (0.21±0.13) also significantly decreased ATSF at post-test compared to the CON (0.39±0.22)($F_{(1,24)=}$4.321, $P$<0.05). No other significant findings were observed ($P$>0.05). **Conclusion:** Female youth soccer players are able to reduce ATSF and VRGF after receiving one session of instruction on proper landing mechanics. This indicates that augmented feedback may be effective in preventing ACL injuries in youth athletes.

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**The Effect Of Instruction On Jump-Landing Kinematics In College Age Female Athletes Over Time**

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**Context**: The use of verbal and video instruction is a feedback tool that can be implemented into many clinical rehabilitative and prevention programs; it has been utilized in an attempt to decrease the biomechanical risk factors associated with anterior cruciate ligament (ACL) injuries. **Objective**: To determine whether self or a combination of self and expert video feedback will have an effect on box-drop jump (BDJ) and running-stop jump(RS) lower extremity kinematics in college females. **Design**: Randomized controlled. **Setting**: Controlled Laboratory. **Participants**: 43 physically active females (age=21.47 ±1.55years, mass= 63.78±12kg, height=1.65 ±0.08m) with no history of an ACL or lower extremity injury or surgery in the past two months were randomly assigned to three groups;15 self feedback(self),15 combination feedback(combination),and 13 control. **Interventions**: Subjects performed a BDJ for pretest and then received self, combination or no video and verbal feedback about their landing mechanics. Following the intervention, they performed a posttest and a retention test one month later of the BDJ and a RS test. Kinematic data were collected during 5 trials of each task with an eight-camera high-speed system sampled at 500Hz (VICON Motion System). **Main Outcome Measures**: The independent variables included feedback group (self,combination,control), test time (Pretest, Posttest, Retention), and task (BDJ,RS). The dependent variables were lower extremity kinematics at initial contact (IC) and at maximum knee flexion (MKF). These included knee (KF) and hip flexion (HF), knee valgus (KV), and hip abduction (HAB). One-way ANOVAs and repeated measures ANOVAs were conducted, with an alpha of 0.05 set *a priori*. **Results**: For the box-drop jump, KF and HF angles at IC were significantly greater at the posttest than retention (-22.5±10.0, -19.5±7.2; and 40.9±9.2, 39.1±7.1, respectively; $p$<0.001). At MKF, HF was significantly greater at posttest (81±12.2) than pretest (76.8±12.1), and retention (80.6±11.4) greater than pretest, $p$<0.05; KF was significantly higher at posttest (-87.2±13) thanP (-83.7 ±11.8) and retention (-84.1±12); HAB was greater at pretest (-4.2±6.5) than posttest (-6.9±6.3) and retention(-7.2±6.1); KV was greater for retention (-2.1±0.3) than pretest (1.4±9.3) and posttest(2.2±9.1,$p$<0.05). KF at MKF was significantly greater for combination (-88.1±12.6) group than self (-80.7± 6.2,$p$=0.03) during box-drop jump at posttest.For the running-stop jump at the posttest, the combination (-76.4±11) group had significantly higher KF at MKF than self (-66.3±10.8) and control (-68±8.1,$p$<0.05). HF at IC was significantly higher at posttest (53±11.8) than retention (49.5±9.7); At MKF, retention (66±12.9) was greater than posttest (62.5±12.5) for HF, as well as for KV (-6.2± 12;—3±9.9, respectively $p$<0.05). **Conclusions**: Our results suggest that feedback involving a combination of self and expert video and verbal instruction is effective at improving peak knee flexion angles during a box-drop and running-stop jump. Also, global combo feedback can improve large joint movements at immediate posttest and one month post-test. Future research needs to focus on instruction focusing on initial contact lower extremity kinematics.

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**Effects Of A Customized Injury Prevention Program On Hip And Knee Kinematics During A Double Leg Squat**

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**Context:** Faulty lower extremity movement patterns are thought to contribute to lower extremity injuries, such as ACL injury. Exercise interventions have subsequently been developed in attempt to change these movement patterns. Previous investigations have commonly used a "one size fits all" program without regard to an individual's specific movement impairments. Research has yet to determine if a customized program is more effective in improving lower extremity movement patterns than a generalized program. **Objective:** To compare the effects of a customized (CUS) and generalized (GEN) exercise program on lower extremity kinematics during a double leg squat (DLS). **Design:** Quasi-experimental. **Setting:** Field laboratory. **Patients or Other Participants:** Forty-six high school basketball players participated in this investigation. Varsity boys and varsity and junior varsity girls' teams were assigned to the CUS program (n=29; age=15.8±1.2yrs; height=174.4±10.2cm; mass=69.1±11.3kg). Junior varsity and freshman boys' teams were assigned to the GEN program (n=17; age=14.7±0.7 yrs; height=175.8.4±10.1cm; mass=67.35±9.9kg). **Interventions:** The GEN program emphasized increasing lower extremity neuromuscular control through single plane functional exercises such as lateral shuffles and walking lunges. Individuals assigned to the CUS program were provided exercises based on their performance of a standardized DLS. All participants in the CUS group performed multi-directional functional exercises such as multi-directional lunges and hop-to-balance, along with either hip flexibility/strengthening exercises or calf flexibility/strengthening exercises. Participants were instructed to perform the exercises a minimum of three times per week. A three-dimensional electromagnetic tracking system was used to measure hip and knee kinematics during five trials of a DLS prior to and following the incorporation of the CUS and GEN programs during a 12-week basketball season. **Main Outcome Measures:** Peak kinematics at the hip (flexion, adduction and internal rotation) and knee (flexion, valgus and internal rotation) were averaged across the 5 trials for the stance phase (descent and ascent phase combined) of the DLS. A change score was then calculated for each kinematic variable (post test angle-pretest angle). Separate one-way ANOVAs were performed to compare change scores between the CUS and GEN programs ($\alpha$=0.05). **Results:** Change scores for hip adduction (GEN=2.3±6.5°,CUS=-1.6± 5.4°,$F_{(1,45)}$=5.0, $P$ =0.031) and hip internal rotation (GEN=8.1±8.8°, CUS=1.4 ±11.1°, $F_{(1,45)}$=4.6, $P$=0.037) were significantly different between the CUS and GEN programs. There were no significant differences in change scores for knee flexion (GEN=13.9±11.4°, CUS=12.1±12.2°, $P$=0.61), knee valgus (GEN=.91±3.3°, CUS=2.1±5.3°, $P$=0.39), knee internal rotation (GEN= 1.80±11.1°, CUS=3.7±8.4°, $P$=0.51), or hip flexion angle (GEN= 17.8±13.2°, CUS=18.1±1°, $P$=0.94). **Conclusions:** Following the intervention, individuals participating in the GEN program moved into more hip adduction and hip internal rotation during the DLS. Based on this, we may conclude that the CUS injury prevention program may be more beneficial than a "one size fits all" program when attempting to correct lower extremity movement impairments.

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**Identifying Kinematic and Coordinative Changes in the Lower Extremities During Walking and Running More Than One Year After Anterior Cruciate Ligament Reconstructive Surgery**

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**Context:** Previous findings suggest that sagittal knee kinematics during self-selected walking speeds return to healthy levels within a year of anterior cruciate ligament reconstruction (ACLR). However, evidence reveals that the coordination within and between limbs are altered on a long-term basis despite ACLR. Furthermore, little is known about sagittal knee kinematics at conditions beyond comfortable walking speeds following ACLR. **Objective:** To identify changes in the amount and timing of knee flexion angles during stance phase more than one year after ACLR, using healthy subjects and a systematic velocity manipulation as a frame of reference. **Design:** Repeated measures with one between-group factor (ACLR subjects vs. healthy controls) and two within-group factors (surgically involved vs. uninvolved leg; velocity). **Setting:** An Optotrak 3020 System collected three-dimensional kinematic data at a frequency of 100 Hz while participants walked and ran on a Kistler/Trotter treadmill. **Participants:** Nine ACLR subjects (6 females; age=27.1±4.5 y/o; height=170.2±7.2 cm; weight=71.2±13.4 kg) and eleven healthy subjects (5 females; age=23.2±7.2 y/o; height=170.5±8.2 cm; weight=63.1±11.6 kg) participated. ACLR subjects underwent allograft ACLR 2.1±0.6 years ago and were cleared for unrestricted physical activities by an orthopedic surgeon. **Interventions:** Independent variables included Body Side (BS) [ACLR involved leg (ACLR-IL); ACLR uninvolved leg (ACLR-UL)], Group (G) [ACLR-IL; Healthy control leg (H-CL)], and Velocity [nine conditions]. Velocity (V) was systematically increased from 0.3 to 2.7 m/s by increments of 0.3 m/s every 60 seconds, and subsequently decreased in similar steps. **Main Outcome Measures:** Dependent variables included knee flexion angles at heel strike (KFH) and maximum knee flexion (MKF) as well as the timing of MKF (TMK) during stance phase. Two separate ANOVA with repeated measures were utilized to assess the main and interaction effects of BS and V as well as G and V. **Results:** Significant BS main effects for the means of KFH [p=0.02; F(1,00)=7.49] and MKF [p=0.03; F(1,00) =7.70] indicated that ACLR-IL exhibited smaller knee flexion angles than the ACL-UL during stance phase across all speeds. Significant G*V interaction effects for the means of KFH [p<0.01; F(2,07)=6.52] and MKF [p=0.02; F(2,59)=4.01] indicated that the ACLR-IL showed larger knee flexion angles than the H-CL at speeds lower than 1.2 m/s but smaller angles at speeds higher than 1.5 m/s. Differences in TMK approached significance as MKF occurred later in the stance phase at lower walking speeds in the ACLR-IL compared to the ACLR-UL [p=0.07; F(1,00)=4.29] and H-CL [p=0.06; F(2,76) =2.69]. **Conclusions:** Despite surgical intervention, the ACLR-IL exhibits long-term changes in the amount and timing of knee flexion during stance phase as compared to ACL-UL and C-HL, particularly at speeds beyond comfortable walking. These findings support previous recommendations that velocity conditions beyond comfortable walking speeds should be incorporated into gait retraining protocols following ACLR. Funded by the NATA Foundation Doctoral Research Grant Program.

**Instrumented And Clinical Measures Of Postural Control Are Predictors Of Chronic Ankle Instability**


Hebert L, Mattacola CG, Mullineaux DR, McKeon PO: University of Kentucky, Lexington, KY, and Cedarville University, Cedarville, OH



**Context:** Chronic ankle instability (CAI) is a condition involving recurrent ankle instability following an initial lateral ankle sprain. Postural control deficits related to CAI have been assessed using both the Balance Error Scoring System (BESS) and Time-to-boundary (TTB) measures. Independently, these measures have been able to detect deficits in postural control; however, it is unknown how these are related. **Objective:** To determine the relationship between BESS and TTB measures as predictors of those with and without CAI. **Design:** Case-control study. **Setting:** All tests were performed in a university laboratory. **Patients or Other Participants:** Fourteen subjects with self-reported CAI (age: 26.0±6.5 years, mass: 73.2±15.4 kg, height: 169.0±6.7 cm, Foot and Ankle Ability Measure Sport (FAAMS): 68.5±18.1%) gender and side matched to 14 healthy subjects (age: 24.1±2.7 years, mass: 72.2±15.1 kg, height: 168.3±4.9 cm, FAAMS: 99.8±0.8%). **Interventions:** All subjects performed three 10-second trials on each leg with both eyes open and eyes closed on a forceplate. Subjects then performed the BESS single-limb stance test for 20 seconds on each limb on both firm and foam surfaces. **Main Outcome Measures:** The absolute TTB minimum, mean of TTB minima, and standard deviation of TTB minima with eyes open and eyes closed in both the anterior-posterior (AP) and medial-lateral (ML) directions, and number of errors for each BESS condition. Independent t-tests were run for all variables to determine significant differences between groups. Pearson- product moment correlations were calculated across all significant variables. Significant uncorrelated variables were entered into a logistic regression to discriminate between CAI and healthy. Alpha level was set a priori at $p \leq 0.05$. **Results:** CAI subjects had significantly lower TTBAP measures than controls with eyes open: absolute TTBAP minimum (Control: 1.83±0.39s, CAI: 1.28±0.38s, p=0.001), the mean of TTBAP minima (Control: 6.18±1.07s, CAI: 4.99±1.22s, p=0.01), and the standard deviation of TTBAP minima (Control: 4.05±0.92s, CAI: 3.27±1.01s, p=0.04). CAI subjects had significantly more errors on the BESS firm condition than the control group (Control: 1.36±1.29 errors, CAI: 2.71±1.64 errors, p=0.03). All TTB measures were significantly correlated to each other (all $r>0.56$, all $p<0.01$), but not with the BESS errors (all $r<.23$, all $p>0.20$). Because TTB measures were highly correlated, the mean of TTBAP minima with eyes open was chosen as the representative measure of TTB. In the logistic regression, the mean of TTBAP minima was a significant predictor of group membership (p=0.04) whereas the BESS firm was marginally significant (p=0.055). Together they classified 71% (10 of 14) of the subjects in each group correctly. **Conclusions:** Postural control deficits in CAI were found using both TTB and BESS. TTB and BESS measures were not significantly correlated and likely measure different aspects of postural control. These measures can be used together to best detect CAI.


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**Microneurographic Evaluation Of Afferent Deficits In The Unstable Ankle During Anterior Loading And Inversion Stress**


Needle AR, Swanik CB, Farquhar WB, Thomas SJ, Kaminski TW: University of Delaware, Newark, DE



**Context:** Ankle sprains are very common in athletics, accounting for nearly 15% of all injuries. A debilitating condition, ankle instability, develops in 30 to 80 percent of persons suffering ankle sprains, and is associated with repeated, unanticipated episodes of "giving way" or "rolling." The presupposed relationship between mechanical laxity and ankle instability has been inconclusive suggesting the cause for instability may not be structural, but insufficient sensorimotor function and dynamic restraint. An alternate theory for the development of ankle instability involves deafferentation of the peripheral mechanoreceptors, resulting in decreased afferent traffic and loss of sensation. However, direct evidence confirming isolated peripheral sensory deficits has been elusive because previous research relied upon subjective perceptions of ankle proprioception or kinesthesia. **Objective:** The purpose of this study was to explore the relationship between mechanical laxity, instability, and sensation by simultaneously measuring peripheral afferent nerve traffic, joint loading and motion in a comparison between healthy ankles and those with with control group. **Setting:** Human Performance Laboratory. **Patients or Other Participants:** Recordings were obtained on 29 subjects stratified into a healthy control group (C, 19 subjects, 21±2.3yrs, 172.8±9.4cm, 75.4±13.1kg) or ankle instability group (AI, 10 subjects, 20.6±2.1yrs, 173.7±8.1cm, 72.7±12.3kg) based on scores of the Cumberland Ankle Instability Tool (C: 29.4±.8, AI: 17.4±5.5). **Interventions:** The independent variables were group, and levels of force, torque, displacement and rotation. Sensory traffic from muscle spindle afferents in the peroneal nerve was recorded using microneurography while anterior translation (AP) and inversion rotation (IE) stress was applied to ligamentous structures utilizing a customized instrumented ankle arthrometer. **Main Outcome Measures:** The dependent variables were amplitude of afferent traffic (%) and mechanical laxity (mm or deg) determined at 0, 30, 60, 90, and 125 N of AP force; and 0, 1, 2, 3, and 4 Nm of IE torque. Two-factor repeated-measure analyses of variance were used to compare laxity and afferent amplitude at predetermined forces and torques between groups. **Results:** No differences in mechanical laxity were seen between healthy and unstable ankles (C: 8.3±2.4mm, AI: 7.2±2.0mm, $p>.05$). Afferent traffic increased significantly with increased force, torque, translation and rotation ($p<.001$).The AI group displayed a decrease in afferent activity at 30 N of anterior force compared to the control group (C: 30.2±9.9%, AI: 17.1±16.1, $p<.05$). **Conclusions:** The amplitude of peripheral afferent traffic increases simultaneously with greater ankle motion and loading, supporting the integrated sensory role of capsulo-ligamentous and musculotendinous mechano-receptors in maintaining joint stability. However, unstable ankles had diminished afferent traffic at low levels of force suggesting that the early detection of joint loading may be compromised. This impairment may delay or modify the appropriate sensorimotor responses necessary for dynamic stability and alter cognitive appreciation of an impending "roll-over" event. Funded by the NATA Foundation Master's Research Grant Program.


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**Reactive Knee Stiffening Is Diminished Under Cognitive Loads**

Kim AS, Swanik CB, Higginson C, Thomas SJ, Kaminski TW: Department of Health, Nutrition and Exercise Science, Human Performance Laboratory, University of Delaware, Newark, DE, and Department of Psychology, Loyola University Maryland, Baltimore, MD

**Context:** Muscle stiffness regulation is critical to maximize dynamic restraint and maintain knee stability in response to joint loading. Knee injuries have recently been associated with sub-optimal neurocognitive performance in athletes. This suggests certain mental tasks may momentary compromise the execution of muscle activation strategies necessary for stiffness regulation and the absorption of joint loads. **Objective:** To determine reactive knee stiffness levels under various cognitive loads including visuospatial, verbal, and mathematical tasks. **Design:** A single group repeated measures post test only study. **Setting:** This study was performed in a controlled laboratory setting. **Participants:** Seventeen (8 males, 9 females) healthy college aged participants (age = 20.4 ± 1.7 yrs, height = 170.8 ± 9.3 cm, mass = 69.5 ± 15.1 kg) with no current injury or previous surgery to their dominant lower extremity. **Interventions:** The independent variables were the type of cognitive tasks administered, which included the Benton Judgment of Line Orientation (JOLO), Symbol Digit Modalities Test (SDMT), Serial 7's, and a control condition. A custom-made Stiffness and Proprioception Assessment Device (SPAD) was used to measure reactive knee stiffness. Participants were seated in the SPAD with the testing leg in 30° of knee flexion. They were then instructed to perform one of the three cognitive tasks or the control condition. During this period (approximately 10 seconds) they were instructed to react to a randomly timed knee flexion perturbation (excursion = 40°, velocity = 100°/sec, acceleration = 1000°/sec$^2$). Reactive stiffness was measured from the starting position of 30° knee flexion to the end of the 40° perturbation. Data was processed using customized LabVIEW software (National Instruments, Austin, Tx). An analysis of variance with repeated measures was used to analyze the differences in reactive knee stiffness between the cognitive tasks and a control condition. **Main Outcome Measures:** Total knee stiffness measurements were calculated and recorded as torque (Nm) / position (degrees). **Results:** Reactive knee stiffness values were significantly different between the three cognitive tasks and the control condition (JOLO = 2.08±0.780 Nm/deg, SDMT = 2.22±0.810 Nm/deg, Serial 7's = 2.32±0.801 Nm/deg, and control = 3.15±0.675 Nm/deg, $p<0.001$). However, there were no significant differences found between each of the three cognitive tasks. **Conclusions:** Different kinds of cognitive tasks may all decrease the ability of healthy individuals to reactively stiffen their knee joint. Cognitive loading appears to interfere with the normal force attenuating properties of eccentric muscle contractions, which impairs the dynamic restraint mechanism and may expose individuals to joint injury. This suggests caution should be used when implementing cognitive loading as a modality to increase the level of difficulty during prevention and rehabilitation programs. Continued research is needed to determine which neurocognitive factors most influence muscle activation strategies and stiffness regulation. Funded by the NATA Foundation Master's Research Grant Program.

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**Fatigue Alters Lower Extremity Landing Biomechanics In Both Genders**

Wesley CA, Aronson PA, Docherty CL, Schrader JW: Indiana University, Bloomington, IN, and Lynchburg College, Lynchburg,VA

**Context:** Gender differences in landing biomechanics may play a role in the increased rate of ACL injuries in female athletes. Fatigue may negatively affect landing mechanics, resulting in higher injury risk, but little is known regarding gender differences in response to fatigue. The Landing Error Scoring System (LESS) allows for evaluation of landing technique in a clinical setting. Objective: To use the LESS to determine the effects of fatigue on the landing biomechanics of males and females. **Design:** Testing occurred in a single test session and employed a repeated measures design (pre-post test). **Setting:** Research laboratory setting. Patients or Other **Participants:** Thirty-six (18M, 18F) healthy collegiate varsity, club, and intramural athletes (age=19.3±1.2 years, height=177.2±10.9cm, mass=74.2±13.8kg, years of experience in current sport= 8.4±4.7 years) volunteered to participate in this study. Subjects were excluded if they had any history of ACL injury or surgery, or had participated in an ACL injury prevention program or received landing instruction. **Interventions:** Jump landing technique (using the LESS) and vertical jump height were evaluated before and after performance of a functional fatigue protocol. The LESS involves performance of 3 jump landing tasks from a 30cm box. Jumps were recorded in the frontal and sagittal planes using 2 standard video cameras (Sony, Inc., Tokyo, Japan). Then, using the LESS rubric, each jump was scored based on several biomechanical factors such as knee flexion angle, stance position, and knee valgus angle. A point corresponded to each error committed. A higher LESS score indicates a greater number of errors committed and therefore poor jump landing technique. The fatigue protocol consisted of sprinting, jumping, and cutting tasks, which was repeated until the subject reached a fatigued state. Fatigue was defined as a 2" decrease in vertical jump height, measured using a Vertec device (Sports Imports, Columbus, OH). **Main Outcome Measures:** The mean of the 3 LESS scores in each condition (pre-test and post-test) was used for statistical analysis. A repeated measures ANOVA was used to identify performance differences between genders (male and female) and fatigue status (pre-test and post-test). **Results:** Results revealed a significant main effect for gender ($F_{1,34}$=4.40, P=.04) and fatigue status ($F_{1,34}$=24.65, P=.01). Females scored significantly higher (6.28±0.44) on the LESS (committing more errors) than males (4.96±0.44). Post-test scores were significantly higher (6.26±0.34) than pre-test scores (4.98±0.34) for all subjects. No fatigue status by gender interaction was identified ($F_{1,34}$=.25, P=.62). **Conclusions:** Females demonstrate harmful landing characteristics that may contribute to their increased rate of ACL injury. Both genders demonstrate poor technique as a result of fatigue, but females are not affected to a greater degree than males. Both genders may be at higher risk of ACL injury in the presence of fatigue.

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**Neuromuscular Changes After Aerobic Exercise In ACL Reconstructed Individuals**

Dalton EC, Jackson KR, Weniger GR, Ingersoll CD, Hart JM: Atlantic Physical Therapy, Norfolk, VA; University of Toledo, Toledo, OH; University of Virginia, Charlottesville, VA; Central Michigan University, Mount Pleasant, MI

**Context:** Anterior cruciate ligament reconstructions (ACL-R) are common, especially in young and active individuals. Lower extremity neuromuscular adaptations seen following prolonged exercise will provide information about performance of previously injured patients and highlight deficits and enhance areas for focused treatment. Currently there is little information regarding neuromuscular performance in persons with ACL-R following aerobic exercise. **Objective:** To compare the change in hip muscle force output, dynamic balance, and vertical jump height following aerobic exercise in ACL reconstructed patients compared to matched

healthy controls. **Design:** Case Control. **Setting:** Laboratory. **Patients or Other Participants:** Thirty-six recreationally active subjects consisting of 18 controls: 7 males (25.6±4.4 yrs, 173.8±6.5cm, 76.6±9.6kg) and 11 females (21.9±1.1 yrs 165.7±14.7cm, 62.1±10.5kg); and 18 patients who were at least 2 years post unilateral, primary ACL reconstruction: 7 males (25.6±3.4 yrs, 177.8±10.2cm, 88.9±25.4kg) and 11 females (23.2±6.8 yrs, 168.8±14.1cm, 64.7±10.1kg). **Intervention(s):** All subjects performed a standardized 20 minutes aerobic exercise protocol on a treadmill at 3.5 miles per hour. During the first 15 minutes of exercise, the treadmill incline was increased by 1%. Subjects raised or lowered the treadmill incline during the last 5 minutes to maintain a rating of perceived exertion between 15-17 indicating that the subjects perceived the exercise was "hard(15)-to-very hard(17)." **Main Outcome Measures:** Maximal, normalized reach distances were recorded in the anterior, posterolateral and posteromedial directions of the star excursion balance test(SEBT). Muscle activation was recorded for the gluteus medius during the SEBT with surface electromyography and normalized to quiet stance. Maximal voluntary isometric force for hip extension, hip abduction and hip external rotation was normalized to mass. Maximal, single-leg vertical jump height was measured in meters. Individual 2 x 2 mixed model MANOVAs were used to compare pre-post exercise variables **Results:** On average, ACL-R subjects exhibited shorter reach distances compared to controls during posteromedial (0.94±0.3 vs 0.85±0.3, $F_{1,33}$=5.24,*P* =0.03,$h^2$ =0.14) and posterolateral reach tasks (0.90±0.3 vs 0.81±0.3, $F_{1,33}$= 6.10,*P*= 0.02,$\eta^2$=0.16) and exhibited less gluteus medius muscle EMG activation during the anterior reach task (0.86±0.04 vs 1.02±0.4, $F_{1,33}$=7.51,*P* =0.01,$\eta^2$= 0.20). All subjects experienced reductions in normalized hip abduction(0.83± 0.22 vs 0.78±.26,$F_{1, 33}$=-4.1, *P*= 0.05, $\eta^2$= 0.11 and extension strength (0.47±0.21 vs 0.41±0.17, $F_{1, 33}$= 6.2, *P*= 0.02, $\eta^2$= 0.16) after exercise however, ACL-R patients exhibited greater hip extension strength loss (average reduction: 21.2%) following aerobic exercise than controls (average reduction: 2.3%). There were no differences in vertical jump height over time or between groups. **Conclusions:** Neuromuscular deficits following aerobic exercise exist in both ACL-R patients and controls. ACL-R subjects may be experiencing greater deficits in hip extension strength following aerobic exercise. Reduced reach distances in ACL reconstructed individuals may represent a protective mechanism against excessive tibiofemoral rotation during dynamic balance.

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# Free Communications, Oral Presentations: Doctoral Student Award Finalists

Wednesday, June 23, 2010, 9:30AM-10:45AM, Room 203AB, Moderator: Kim Peer, EdD, LAT, ATC

### Joint Mobilization Improves Spatiotemporal Postural Control And Range Of Motion In Those With Chronic Ankle Instability

Hoch MC, Staton GS, McKeon PO: University of Kentucky, Lexington, KY

**Context:** Individuals with chronic ankle instability (CAI) have demonstrated impaired postural control and decreased dorsiflexion range of motion (ROM). Joint mobilization (JTMOB) may assist in improving postural control and restoring ROM in this group. **Objective:** Examine the effect of a single posterior talar glide JTMOB treatment on time-to-boundary (TTB) postural control and dorsiflexion ROM. **Design:** Randomized crossover study. **Setting:** Research laboratory. **Patients or Other Participants:** Twenty individuals with self-reported CAI (9 males,11 females, age:23±5.5 years, height:174.6±7.8, weight:76.9±14.8) participated in two separate testing sessions. Subjects were included if they reported at least one ankle sprain, two episodes of ankle "giving way" in the past three months, and disability scores of ≤ 90% on the Foot and Ankle Ability Measure (FAAM) and d"80% on the FAAM-Sport. Subjects who reported bilateral CAI were tested on the self-reported worse limb. **Intervention(s):** On each test session, subjects either received two, 2-min repetitions of posterior talar glide JTMOB consisting of 1-sec oscillations at the point of tissue restriction or rest for 5 min. On both days, subjects performed three, 10-second trials of barefoot single-limb stance on a forceplate with eyes open (EO) and eyes closed (EC). Subjects also performed three trials of the weight-bearing lunge test to assess dorsiflexion ROM. The mean of each measure was used for analysis. Independent variables included treatment (JTMOB, control) and vision (EO, EC). **Main Outcome Measures:** The mean of TTB minima and the standard deviation of TTB minima in the mediolateral (ML) and anteroposterior (AP) directions and dorsiflexion ROM (cm) were the dependent variables. Separate treatment by vision ANOVAs were used to compare each TTB variable. Post-hoc paired sample t-tests were calculated to explain significant interactions. A paired sample t-test was used to compare dorsiflexion ROM. The alpha level was set at p≤0.05. **Results:** Significant treatment by vision interactions were found for the mean of TTBAP minima (p=0.001), the standard deviation of TTBAP (p=0.001), and the mean of TTBML minima (p=0.03). Post hoc analyses revealed significantly higher TTB values for the JTMOB treatment for the mean of TTBAP minima with EO (JTMOB: 5.93±1.40 s, Control:4.95±1.05 s, p<0.001) and the standard deviation of TTBAP minima with EO (JTMOB:3.85 ±1.03 s, Control: 3.04±0.86 s, p<0.001). However, no difference was detected for the mean of TTBML minima with EO (p=0.07). There were no differences between JTMOB-EC values and control-EC values in either direction. For both treatments, TTB-EO values were significantly higher than TTB-EC values (p<0.001). A significant increase in dorsiflexion ROM was detected after JTMOB treatment compared to control (JTMOB:12.62±cm, Control:12.20±3.01cm, p=0.01). **Conclusions:** One posterior talar glide JTMOB treatment significantly improved spatiotemporal postural control and dorsiflexion ROM. This indicates that incorporating JTMOB into rehabilitation can improve sensorimotor function and arthrokinematic restrictions experienced by those with CAI.

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### A Pediatric ACL Injury Prevention Program Improves Landing Biomechanics In Youth Soccer Athletes

DiStefano LJ, Padua DA, Stephenson LJ, Blackburn JT, Garrett WE, Guskiewicz KM, Marshall SW: University of Connecticut, Storrs, CT; University of North Carolina, Chapel Hill, NC; Duke University, Durham, NC

**Context:** ACL injury prevention programs may be more effective if they are implemented before children reach ages associated with highest injury risk. Previous research suggests that athletes under twelve years may require a modified ACL injury prevention program that accounts for differences in development between children and adults to change potential injury risk factors. **Objective:** To compare the effects of pediatric and traditional ACL injury prevention programs on lower extremity biomechanics in youth soccer athletes. We hypothesized the pediatric program would be the most effective program for modifying

biomechanics. **Design:** Randomized controlled trial. **Setting:** Research laboratory. **Patients or Other Participants:** Fifty-nine healthy youth soccer athletes from seven teams (Males: n=34, mass=34.4±5.4 kg, height= 142.9± 6.3 cm, age=10±1 years; Females: n=25, mass=33.1 ±5.0 kg, height=140.3±6.5 cm, age=10±1 years) volunteered to participate. Teams were cluster-randomized to either a pediatric (n=19) or traditional (n=19) injury prevention program or a control group (n=21). **Interventions:** Teams assigned to either the pediatric or traditional program completed the program as part of their normal soccer warm-up 2-3 times per week for 9 weeks. The pediatric program was modified from previous ACL injury prevention programs to include basic progressions, additional time for feedback, and increased exercise variety. The traditional program was similar to previous programs. The control group did not perform any program. Participants completed three trials of a jump landing task before (PRE) and after (POST) the intervention period. Participants jumped forward from a 30-cm high box a distance of half their body height, landed with their dominant foot on a force plate and jumped for maximal vertical height upon landing. An optical motion analysis system was synchronized with the force plate to measure three-dimensional joint kinematics and ground reaction forces. **Main Outcome Measures:** Change scores (POST-PRE) of three-dimensional knee kinematics at initial ground contact, peak angles during the stance phase, and peak vertical ground reaction force (VGRF) normalized to bodyweight were calculated using the average of the three trials. Separate univariate ANOVAs were performed for each dependent variable to evaluate differences between groups ($\alpha \leq .05$). Independent samples t-tests with a Bonferroni correction were used for post-hoc analyses. **Results:** The pediatric program (Kneeflexion PRE=73.81± 6.94, POST =89.55± 14.79; VGRF: PRE =3.65±0.78, POST =2.85±0.70) significantly increased peak knee flexion ($F(2,55)=4.39$, $P=0.02$) and decreased peak VGRF ($F(2,55)=3.78$, $P=0.03$) compared to the control group (Knee flexion: PRE= 76.53±10.77, POST =80.59± 15.10; VGRF: PRE=3.70± 0.39, POST= 3.70±1.33). No other significant differences were observed ($P>0.05$). **Conclusions:** Previous research investigating ACL injury youth athletes. Our findings indicate a pediatric ACL injury prevention program designed for children can improve sagittal plane landing biomechanics in ten-year old athletes. These findings are promising for intervening with children early in development to prevent ACL injuries.

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**Comparisons Of Sagittal Plane Hip And Knee Biomechanics In Males And Females During A Cutting Task When Relative Demands Are Controlled**

Montgomery MM, Schmitz RJ, Shultz SJ: The University of North Carolina at Greensboro, Greensboro, NC

**Context:** Females typically have less strength per unit body mass than males. Whether commonly observed sex differences in knee biomechanics during standardized height and distance laboratory tasks are partly due to greater relative demands placed on females during these tasks is unknown. **Objective:** We examined sex differences in sagittal plane hip and knee biomechanics during a bound and side-cutting task where the bound distance was normalized to an individual's maximum capability. Our expectation was that no sex differences would be observed in sagittal plane knee kinematics and kinetics when the task was normalized in this manner. **Design:** Descriptive between-subject. **Setting:** Controlled laboratory. **Participants:** Male (n=15; 20.1±1.2yrs; 180.7±8.2cm; 79.1±8.9kg) and female (n=9; 20.1±1.3yrs; 167.7±6.5cm; 66.8.±9.3kg) intercollegiate athletes. **Interventions:** Participants performed a single leg bound equal to 80% of their maximum bound distance, followed immediately by a 60° side cut. Participants were instructed to perform the task as quickly as possible. 3D kinematic (°), kinetic ($Nm/kg*m^{-1}$), anterior knee shear force (AKSF) (body weights (N)) and vertical ground reaction force (vGRF) (body weights (N)) data were recorded from the dominant limb. **Main Outcome Measures:** Hip and knee flexion at initial contact (HFIC, KFIC) and total excursion (HFEXC, KFEXC), peak hip and knee extensor moments (HEM,KEM), and peak AKSF and vGRF were recorded during the deceleration phase of the side-cut (foot contact to peak knee flexion). One-way ANOVAs examined sex differences in approach velocity (average horizontal velocity during 150ms prior to foot contact), and each of the kinematic and kinetic variables. **Results:** The average approach velocity was significantly greater for males than females (3.2±0.3 vs. 2.9±0.2 m/s; p=0.021). However, there were no differences between males and females in HFIC (64.0±8.8 vs. 62.0±16.0°; p=0.708) or HFEXC (14.7±5.2 vs. 14.8.6±5.8°; p=0.985), KFIC (34.5±6.4 vs. 32.1.0±5.8°; p=0.370) or KFEXC (24.9±7.4 vs. 23.0±6.7°; p=0.535), peak HEM (-3.3±0.9 vs. -3.1±0.9 $Nm/kg*m^{-1}$; p=0.584) or KEM (0.1±0.4 vs. 0.2±0.3 $Nm/kg*m^{-1}$; p=0.667), peak AKSF(0.7±0.1 vs. 0.7±0.2 BW; p=0.549), or peak vGRF (2.0± 0.1 vs. 1.9±0.2 BW; p=0.299). **Conclusions:** No sex differences were observed in sagittal plane hip and knee biomechanics when intercollegiate athletes performed a cutting task with an approach distance individualized to their maximum single leg bound distance. Because lower extremity muscle strength largely influences single leg bound ability, it appears that observed sex differences in sagittal plane knee biomechanics during cutting tasks may be partly due to sex differences in relative strength capabilities. These findings may provide insight into the influence of relative strength differences in men and women on hip and knee biomechanics.

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**Determining Sensitive Measures For Detecting Balance Deficits Associated With Unstable Ankles**

Linens SW, Ross SE, Pidcoe P, Gayle RC, Arnold BL: Virginia Commonwealth University, Richmond, VA

**Context:** A variety of balance tests have differentiated stable and unstable ankles. However, few studies have determined cutoff scores for measures sensitive for detecting balance deficits associated with functional ankle instability (FAI). **Objective:** To determine cutoff scores for balance measures sensitive for detecting balance deficits associated with FAI. **Design:** Case control study. **Setting:** Research Laboratory. **Participants:** Subjects with FAI had a history of ankle sprains and symptoms of "giving way" (N=17; 168±9 cm; 68±12 kg; 23±4 yrs) and subjects with stable ankles had no history of ankle injuries (N=17; 168±8 cm; 66±12 kg; 23±3 yrs). **Interventions:** Subjects performed single leg balance on their test legs (leg with FAI or side-matched test leg for subjects with stable ankles). Subjects performed 3 static balance tests: 1-Balance Error Scoring System (BESS); 2-Time-In-Balance (TIB); and 3-Foot Lift Test (FLT). Static balance tests were randomized and required subjects to remain as motionless as possible. Subjects then performed 3 dynamic balance tests: 1-Star Excursion Balance Test (SEBT); 2-Side-To-Side Hop (SSH); and 3-Figure-Of-Eight Hop (FEH). The SEBT was performed first and then SSH and FEH were tested in random order. The SEBT required subjects to stand on their test leg and reach for maximum distance with their contralateral leg in 3 directions (anteromedial, medial, posteromedial). Subjects completed SSH and FEH tests as quickly as possible on their test legs. Cutoff scores for identifying balance deficits associated with FAI were determined for measures with significant receiver operating characteristic (ROC) curves (asymptotic

significance=.05). A cutoff score was determined by the score with the greatest true positive (TP) and least false positive (FP) scores. Positive likelihood ratio (PLR) and negative likelihood ratio (NLR) values were calculated to determine the meaningfulness of cutoff scores. **Main Outcome Measures:** Balance was quantified with total errors (score) for the BESS, length of time balancing (s) for TIB, frequency of foot lifts (score) for FLT, distance reached (normalized to leg length) for SEBT, and time (s) to complete SSH and FEH tests. **Results:** Significant ROC curves were found for TIB (P=.02), FLT (P=.01), posteromedial reach SEBT (P=.04), and SSH (P=.04). No significance was found for BESS (P=0.25), FEH (P=.12), or anteromedial (P=.13) and medial (P=.13) SEBT. Cutoff scores were 38.77 s for TIB (TP=.70, FP=.24; PLR=3.00, NLR=.38), 4.84 lifts for FLT (TP=.71, FP=.18; PLR=4.00, NLR=.36), .89 for posteromedial SEBT (TP=.65, FP=.29; PLR=2.20, NLR=.50), and 12.88 s for SSH (TP=.65, FP=.18; PLR=3.67, NLR=.43). **Conclusions:** Our PLR (≥2) and NLR (≤.05) for each cutoff score indicated that clinically relevant information was gained. Thus, balance deficits associated with FAI can be identified with TIB scores ≤38.77 s and FLT scores ≤4.84 foot lifts, posteromedial reach SEBT scores ≤.89, and SSH scores ≤12.88 s.

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**Quadriceps And Hamstrings Co-Activation During Common Therapeutic Exercise**

Scanlon-Begalle RL, DiStefano LJ, Blackburn JT, Padua DA: Sports Medicine Research Laboratory, University of North Carolina at Chapel Hill, Chapel Hill, NC

**Context:** Anterior tibial shear force and knee valgus moment increase anterior cruciate ligament (ACL) loading. Co-activation of the quadriceps and hamstrings could potentially decrease anterior tibial shear force and knee valgus moment, thus influencing ACL loading and injury risk. Therefore, identifying exercises that facilitate balanced activation of the quadriceps and hamstrings may be beneficial in ACL injury prevention. **Objective:** To quantify and compare quadriceps/hamstrings co-activation ratios during common closed kinetic chain exercises. **Design:** Cross-sectional. **Setting:** Research laboratory. **Patients or Other Participants:** Twenty-seven physically active volunteers (12 males,15 females, age = 22.1± 3.1 years, height = 171.4 ± 10 cm, mass =72.4 ± 16.7 kg). **Interventions:** Participants completed 8 trials of 9 separate therapeutic exercises in a randomized order: single-leg squat, single-leg deadlift, forward lunge, side lunge, transverse lunge, forward hop-to-balance, side hop-to-balance, transverse hop-to-balance, and lateral walk with Theraband. **Main Outcome Measures:** Surface electromyography (EMG) on the dominant leg (used to kick a ball for maximal distance) was used to quantify the activity level of the vastus medialis (VM), vastus lateralis (VL), medial hamstrings (MH), and biceps femoris (BF) muscles. EMG data were normalized to maximal voluntary isometric contraction. The quadriceps to hamstrings co-activation ratio (Q:H) was computed as a ratio of the average EMG amplitude of the quadriceps (VM and VL) to that of the hamstrings (MH and LH) for each trial. Q:H ratios greater than 1.0 indicate increased quadriceps compared to hamstrings activation, while Q:H ratios less than 1.0 indicate greater relative hamstring activity. Repeated measures analysis of variance was used to compare Q:H ratios across exercises ($\alpha$<0.05), followed by Tukey's post hoc analyses (minimum significant difference = 2.60). **Results:** We observed a significant main effect for exercise ($F_{8,208}$=23.2, $P$<0.001). Tukey's post hoc analyses revealed smaller Q:H ratios during the single-leg deadlift (2.87 ± 1.77) compared to the single-leg squat (5.52 ± 2.89); however, there were no differences between the transverse hop (3.08 ± 1.90), side hop (3.12 ± 1.73), lateral band walk (3.64 ± 1.57), and forward hop (5.26 ± 4.43) exercises. The largest Q:H ratios were observed during the transverse lunge (7.78 ± 5.51, $P$<0.001), side lunge (9.30 ± 5.53, $P$<0.001), and forward lunge (9.70 ± 5.90, $P$<0.001), as Q:H during these exercises were greater than the side hop, lateral band walk, transverse hop, and single-leg deadlift. The side lunge and forward lunge were also significantly greater than the forward hop and single-leg squat. **Conclusions:** The most balanced Q:H ratios were observed during the single-leg deadlift, side hop, transverse hop, and lateral band walk exercises. These exercises should be incorporated to facilitate balanced activation in ACL injury prevention programs. Post-injury rehabilitation programs should also utilize these exercises in a safe and progressive manner.

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# Free Communications, Oral Presentations: Injury Risk Factors

Wednesday, June 23, 2010, 11:00AM-12:00PM, Room 203AB, Moderator: Alison Snyder, PhD, ATC

**Risk Factor Of Medial Tibial Stress Syndrome Among Runners: Mediating Effect Of Gait Kinematics On Medial Tibial Stress Syndrome**

Lee SY, Ingersoll CD, Saliba S, Kerrigan DC, Fan X, Hertel J: University of Virginia, Charlottesville, VA; University of Miami, Coral Gables, FL; Central Michigan University, Mount Pleasant, MI

**Context:** Lower extremity (LE) alignment may not be a risk factor of Medial Tibial Stress Syndrome (MTSS) if it does not alter gait kinematics. Therefore, it is necessary to examine the mediating effect of gait kinematics on MTSS. **Objective:** To investigate the direct and indirect effects of lower extremity alignment and gait kinematic measures on MTSS status. **Design:** A case control design. **Setting:** Laboratory. **Participants:** A total of 74 recreational and competitive runners [37 normal (23.9±.4 years), 37 MTSS injured (24.0±.3 years)] were recruited. **Intervention:** As a result of individual t-test analysis for all potential risk factors (total 33 measures) including LE alignment, and maximum (max) joint kinematics (2.65m/s, 120Hz), variables including navicular drop, standing rearfoot angle, non-weight bearing rearfoot alignment, tibial torsion, Q-angle, femoral anteversion, max hip adduction (hipADD), max hip internal rotation (hipIR), max knee internal rotation (KneeIR), and max eversion (EV) were selected for independent variables. An exploratory factor analysis using principle component analysis was conducted to reduce the dimensionality of the LE alignment measures. The sum of Z-scores of composite measurements was the value of each latent alignment variable. Finally, path analysis was conducted to construct models and identify direct and indirect effects of the alignment and gait measures on MTSS status. **Main Outcome Measure:** The dependent variable was MTSS status. **Results:** The major findings of this study were: (1) LE alignment measures were classified into proximal segment alignment including femoral anteversion, Q-angle, and tibial torsion; and distal segment alignment including navicular drop, standing rearfoot angle, and rearfoot alignment; (2) the proximal segment alignment had a direct effect on MTSS status [p=.021; accounts for 45% of MTSS ($\beta_{MTSS,Proximal}$=.45)] and exhibited an indirect effect on MTSS status by altering hipADD [p=.013; accounts for 5% of MTSS ($\beta_{MTSS,hipADD}$=.20; $\beta_{hipADD,proximal}$=.26)]; (3) the distal segment alignment was only indirectly associated with MTSS status by altering EV

[p=.042; accounts for 11% of MTSS ($\beta_{MTSS,EV}$= -.28; $\beta_{EV,Distal}$=-.40] (4) the proximal segment alignment also had direct effects on hipIR [p=.016; accounts for 38% of hipIR ($\beta_{hipIR,Proximal}$=.38)] and kneeIR [p=.042; accounts for 31% of kneeIR ($\beta_{kneeIR,Proximal}$=.31)], however, these two gait characteristics did not affect MTSS status [p=.21; account for 1% of MTSS ($\beta_{MTSS,hipIR}$=.01) and p=.33; accounts for 10% of MTSS ($\beta_{MTSS,kneeIR}$=.10)]; and (5) the distal segment alignment had direct effects on kneeIR [p=.19; accounts for 27% of kneeIR ($\beta_{kneeIR,Distal}$=.27)], however, kneeIR did not affect MTSS status. **Conclusions:** Clinicians should incorporate interventions to control rearfoot eversion while considering the distal segment alignment and the role of the proximal segment alignment should also be considered to prevent, rehabilitate and diagnose MTSS because it has both direct and indirect effects on MTSS status. Funded by the NATA Foundation Doctoral Research Grant Program.

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**Factors Associated With History Of Lower Extremity Injury Among Military Cadets: The JUMP-ACL Study**

Kucera KL, Marshall SW, Wolf SH, Padua DA, Beutler AI: Division of Occupational and Environmental Medicine, Duke University, Durham, NC; Department of Epidemiology, The University of North Carolina at Chapel Hill, Chapel Hill, NC; Sports Medicine Research Laboratory, The University of North Carolina at Chapel Hill, Chapel Hill, NC; The Uniformed Services University of the Health Sciences, Department of Family Medicine, Bethesda, MD

**Context**: Characterizing the baseline sport participation and injury history of 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 describe baseline sports participation and lower extremity injury history among incoming military cadets. **Design**: Baseline data from the JUMP-ACL Study, a collaborative multi-site prospective cohort study. **Setting**: The three largest U.S. military academies. **Participants**: First year cadets (n=9,811) enrolled 2005 to 2008 in JUMP-ACL.Informed consent and HIPAA authori-zation were obtained from each cadet prior to study enrollment and participation. **Interventions**: Independent variables include self-reported gender, age, regular sports participation during the previous four years, and participation in injury prevention programs (plyometric or ACL specific). **Main Outcomes Measures**: 1) Lifetime history of knee ligament injury and 2) lower leg injury (ankle sprain, shin splints, stress fracture, or bone fracture) within the past six months that limited physical activity participation. Prevalence ratios (PR) and 95% confidence intervals (95% CI) were calculated with multivariate general log-binomial regression models. **Results**: Subjects were predominantly male (75.3%) and 18 to 19 (83.9%) years of age (mean 18.8, SD=0.97, range 16-23). During the four years prior to academy entry, cadets were heavily engaged in sports activities, with a mean of 12.0 sports overall (SD=6.5; range 0-55) and a mean of 3.6 high schools sports (SD=2.2; range 0-16). Frequent high school sports played include track and field (38.9%), football (26.8%), and cross-country (26.4%). Previous knee injuries at baseline included any ligament injury (7.2%) or cartilage/meniscus injury (8.9%). Within the past six months, 44.1% cadets suffered a lower leg injury; 7.0% reported that injury currently limited their physical activities. Adjusting for gender, age, injury prevention programs, and sport, the prevalence of previous knee ligament injury was higher for cadets >19 years of age (PR=1.5, 95% CI: 1.2-1.8) and for those who participated in injury prevention programs (PR=1.7, 95% CI: 1.4-1.9) and in sports with high degree of jumping and cutting (PR=2.1, 95% CI: 1.7-2.6). The prevalence of knee ligament injury increased with increasing number of jumping/cutting sports: one sport vs. none PR=1.9 (95% CI: 1.5-2.5), two sports vs. none PR=2.8 (95% CI: 2.2-3.6). Adjusting for gender, age, injury prevention programs, and sport, the prevalence of lower leg injury currently limiting physical activity was higher for females (PR=1.9, 95% CI: 1.7-2.2), cadets >19 years of age (PR=1.5, 95% CI: 1.3-1.8), and injury prevention program participation (PR=1.2, 95% CI: 1.0-1.4). **Conclusions**: Participation in sports with a high degree of jumping/cutting was associated with higher prevalence of knee ligament injuries while female gender was associated with lower leg injuries at baseline. Cadets >19 years of age enter the academy with higher prevalence of lower extremity injury.

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**The Star Excursion Balance Test As A Predictor Of Lower Extremity Injury In High School Football Players**

Pollock KM, Sato A, Webster KA, Shinohara J, Aminaka N, Pietrosimone BG, Jackson KR, Gribble PA: University of Toledo, Toledo, OH

**Context:** With a high rate of lower extremity injury in sports, researchers and clinicians often seek ways to predict and prevent lower extremity injury. The Star Excursion Balance Test (SEBT) has been shown to be a predictive measure of lower extremity injury in high school basketball players. However, this test has yet to be implemented as a predictive measure in high school football athletes. By utilizing the SEBT as a screening tool, clinicians may be able to identify athletes at risk for injury and recommend proper preventative intervention strategies. **Objective:** To compare pre-season dynamic postural control in high school football players that did and did not suffer lower extremity injury during the competition season. **Design:** Prospective, cohort. **Setting:** High school Athletic Training rooms. **Patients or Other Participants:** One-hundred twenty-one, male high school football players (age:15.9±1.11 yrs; height: 175.64 ±7.92 cm, mass:80.53±14.68 kg) volunteered to participate. **Interventions:** Prior to the 2009 football season, dynamic postural control was measured bilaterally in junior varsity and varsity high school football players using the anterior, posteromedial, and posterolateral directions of the SEBT. Reach distances were recorded in centimeters and normalized by leg length of the stance leg (%MAXD). During the season, the Certified Athletic Trainers at the assigned high schools tracked and reported time lost from traumatic ankle and knee injuries to the researcher. At the end of the competitive season, athletes were placed in an injured (traumatic ankle or knee) or uninjured group, accordingly. Of the 121 athletes initially screened, 24 athletes that reported using a prophylactic brace were not included in this analysis. **Main Outcome Measures**: The normalized means and standard deviations of the anterior, posteriormedial, posteriorlateral and composite (average of the three directions) reaches were compared between the injured (n=19) and uninjured (n=78) groups. Independent t-tests were utilized to compare the four reach scores between the injured and uninjured group. Statistical significance was set *a priori* at p<.05. **Results:** For the four normalized reach scores, significant differences were observed between the injured and noninjured groups in the anterior ($t_{1,98}$=2.54, p=.013; Uninjured: 70.97±7.79 %MAXD, Injured: 66±9.11 %MAXD) and composite ($t_{1,98}$=2.04, p=.044; Uninjured: 75.71±9.05 %MAXD, Injured: 71.39±7.71 %MAXD) scores. No significant differences were noted in the posterolateral ($t_{1,98}$=1.56, p=.121; Uninjured: 70.83±11.55 %MAXD, Injured: 66.47±11.54 %MAXD) and posteromedial ($t_{1,98}$=1.37, p=.172; Uninjured: 84.94±10.26 %MAXD, Injured: 81.67±8.13 %MAXD) scores. **Conclusions:** The results of the study demonstrate that high school football players suffering traumatic ankle or knee injuries during the competitive season presented with a lower level dynamic postural control during the pre-

season assessment. With continued investigation and application, clinicians and researchers may be able to utilize the SEBT as a predictive tool to identify high school football athletes at risk to suffer a lower extremity injury.

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**The Relationship Between Subconcussive Impacts And Concussion History On Clinical Measures Of Concussion In Collegiate Football Players**

Gysland SM, Mihalik JP, Register-Mihalik JK, Trulock SC, Shields EW, Guskiewicz KM: Department of Exercise and Sport Science, Curriculum in Human Movement Science, Campus Health Services, The University of North Carolina, Chapel Hill, NC

**Context:** Recent reports suggest that head impacts sustained during college and professional football careers may be likely contributors to long-term cognitive dysfunction. There is a need to study how repetitive subconcussive impacts sustained in football may influence cognitive function. **Objective:** To investigate the relationship between subconcussive impacts and concussion history on clinical measures of concussion. We hypothesized that a reported history of concussion, a higher number of impacts and cumulative magnitude of head impacts over the course of a single season would explain measurable declines in collegiate football players' clinical measures. **Design:** Quasi-experimental one-group pretest-posttest design. **Setting:** Research laboratory and field setting. **Patients or Other Participants:** Forty-six collegiate Football Bowl Subdivision football players (age=19.65±1.16 years, height=189.43±7.06 cm, mass=112.72±20.75 kg) recruited from a single team participated in this study. **Interventions:** Participants completed a preseason concussion baseline test battery, and repeated this test battery following the end of the regular season. This battery consisted of the Automated Neuropsychological Assessment Metrics (ANAM; computerized neuropsychological test), Sensory Organization Test (SOT; computerized dynamic postural stability evaluation), Standardized Assessment of Concussion (SAC), Balance Error Scoring System (BESS), and Graded Symptom Checklist (GSC). During the season, we used the Head Impact Telemetry (HIT) System during all games and practices to record the linear acceleration data collected by accelerometer-instrumented helmets. Separate multiple linear regression analyses were employed to evaluate whether previous history of concussion, total number of head impacts, total cumulative linear acceleration magnitude of head impacts, and location of head impacts would explain the change in performance of the standard concussion measures. **Main Outcome Measures:** Criterion variables included the change in performance (postseason – preseason) for each of the ANAM modules, SOT equilibrium score, SAC total score, BESS total error score, and GSC total severity score. Explanatory variables included previous history of concussion, total number of head impacts, total cumulative linear acceleration magnitude of head impacts, and location of head impacts. **Results:** We observed a significant relationship between BESS total error score (mean change =1.16±4.13) and our explanatory variables ($F_{7,38}$=3.89; $R^2$=0.33; $P$=0.01). In particular, we found that decreased BESS performance was related to an increase in the total cumulative magnitude of linear acceleration ($P$=0.07). We did not observe any significant relationships for any of the ANAM modules ($P$-values ranged from 0.43 to 0.99). Similarly, regression analyses did not identify any explanatory variables that could explain the changes we observed in the following criterion variables: SAC ($P$=0.28), SOT ($P$=0.08), or GSC ($P$=0.06). **Conclusions:** Changes in performance were mostly independent of previous history of concussion, and the total number, magnitude and location of impacts sustained over one football season. Repetitive subconcussive head impacts over the course of a single season do not result in short-term clinical deficits.

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## Free Communications, Oral Presentations: Unique Injuries in Women Sports

Wednesday, June 23, 2010, 12:15PM-1:15PM, Room 203AB, Moderator: Dawn Minton, MS, ATC

**Rib Injury In An Intercollegiate Women's Soccer Player**

Felton SD, Estes MA, Mandle SM, Guerra JJ: Florida Gulf Coast University, Fort Myers, FL

**Background:** Athlete is an 18 year–old female freshmen soccer athlete. She had no previous history of abdominal or thoracic injury. The athlete was participating in a match during the beginning of the season and fell landing on her right thoracic region. The athlete removed herself from competition due to diaphragm spasm. The athlete was evaluated by the Certified Athletic Trainer (ATC), and physical exam revealed no obvious deformities. Point tenderness was noted over the 10th and 11th Costo-chondral articulations. A rib fracture was ruled out by the ATC following the physical exam and the athlete returned to the competition. **Differential Diagnosis:** Soft Tissue Contusion, Rib Contusion, Intercostal Strain, Oblique Strain, Fractured Rib, Slipping Rib Syndrome **Treatment:** The athlete received intermittent conservative treatment throughout the remainder of the soccer season. Following the season, athlete followed-up with the Team Physician and complained that the condition had not fully resolved. She presented with mild tenderness over the 11th Costo-chondral articulation. Physician further diagnosed the athlete with "probable" Rib Tip Syndrome and instructed athlete to rest over the upcoming semester break. Over the break, athlete sought treatment through chiropractic interventions for "Intercostal neuritis and chondritis". Athlete returned for spring practice and complained of the worse pain ever experienced, especially noticeable while running. Diagnostic imaging included X-ray and Limited Bone Scan which revealed all structures WNL. Later in the spring, athlete had laboratory work conducted to rule out inflammatory arthritis. Laboratory values were WNL. At the end of the spring semester, athlete received a local corticosteroid injection and the team physician instructed her to rest for 2 weeks and slowly begin summer conditioning. The athlete was next seen at the fall PPE and stated no relief in symptoms. At the time, no new clinical signs or symptoms were present and it was decided that the athlete would be treated conservatively throughout the upcoming soccer season and possibly have post-season surgery to resect the 11th rib. Following the soccer season, the athlete was seen by a Cardio-Thoracic surgeon and he was unimpressed with the clinical presentation of the athlete and prescribed on-going conservative treatment with possible surgery in 6 weeks. At the 6-week follow up, surgeon recommended surgery but was uncomfortable performing the actual procedure. Therefore the team physician found a surgeon familiar with this condition and had performed numerous similar surgical resections. Athlete was diagnosed by the new physician with a physical exam and 15 minute treadmill test. Surgery was performed and athlete was inactive for two weeks. At the 6-week follow-up, athlete was allowed to begin light cardiovascular activity and core strengthening.

At 8 weeks post-surgery the athlete was performing functional soccer activities with no sharp pain or symptoms while running, only complaining of mild soreness with core exercises. The athlete has made a full recovery. **Uniqueness:** Rib-Tip Syndrome was first described in 1919 and named in 1922. The condition's signs and symptoms are relatively unknown to healthcare individuals and specifically to ATCs; therefore making proper diagnosis and management complicated. This undiagnosed condition can lead to extended duration of pain, discomfort and worry among the athlete. Therefore this case highlights a rare condition seen in athletics and provides ATCs the clinical presentation of this condition. **Conclusions:** This case highlights the diagnosis of a Rib-Tip Syndrome in an intercollegiate soccer athlete. The athlete has made a full recovery through surgical intervention and rehabilitation. Furthermore, the case highlights the need for the Team Physician to work with the ATC in having an effective treatment plan associated with this unique condition in order to alleviate ongoing athlete pain and discomfort.

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**Occipital Neuralgia In A Collegiate Equestrian Athlete**

Shepherd K, Elliott R, Bryant S, Brown CN, Ferrara MS: University of Georgia, Athens, GA

**Background:** A 19-year-old female equestrian athlete reported to the athletic training room complaining of left side back pain following a fall from a horse. Upon evaluation, the athlete was diagnosed and treated for an erector spinae strain. She reported no head injury and no other symptoms. Pain resolved with conservative treatment in ten days. Three weeks post injury she complained of severe headache post-workout. She stated the pain was sharp, throbbing and localized to the left occipital region, rating it as 8/10. She reported brief dizziness, tinnitus and a family history of migraines. Headaches continued with exertion and decreased with rest for a week. The headaches began to increase in intensity and became constant and unchanged by activity. She also reported brief episodes of tachycardia with heart rates reaching 170 bpm and slightly elevated blood pressure at 135/83 mmHg. Symptoms increased to 5 episodes of tachycardia daily, including sweating, shakiness, and severe burning in the back of her head. Her headaches interfered with schoolwork and sport participation. **Differential Diagnosis:** Exertional-headaches, migraines, supra-ventricular-tachycardia, pheochromocytoma, occipital-neuralgia. **Treatment:** At the onset of headaches an MRI and MRA of the head and cervical spine were ordered and came back negative. She was allowed to resume activities as tolerated. Headaches continued and she was diagnosed with migraines and given a prescription for Midrin (Isometheptene Mucate 65mg, Acetaminophen 325mg, Dichioraiphen-azone 100mg), which provided no pain relief. She was referred to a Neurologist, who diagnosed migraines and tried treatment with Maxalt (5 mg), Topamax (25mg), Frova (2.5mg), Imitrex (100mg), Percocet (325mg), Naprosyn (500mg), and Nortriptiline (10mg). Each medicine was tried one at a time for a period of about three days. None provided pain relief and she experienced adverse side effects (dilated pupils and dizziness) with each medication. He believed the headaches were musculoskeletal and stress induced so massage therapy and sessions with the sports psychologist were prescribed but gave minimal relief. She began team activities and practicing as tolerated. An IV mixture of Reglan (500-cc) and Benedryl (25-mg) she received in the emergency room and once at the Health Center after seeking treatment for pain provided relief. At the onset of heart palpitations she wore an event monitor and was referred to a cardiologist who ordered an Intracardiac Electrophysiology study to rule out supraventricular-tachycardia. This study was negative and an ablasion was not needed. The headaches and palpitations continued, the team physician ordered a 24-hour urine test and specific blood work to rule out an increase in stress hormones caused by pheochromocytomas. These tests were also negative. She was referred to a headache specialist who diagnosed her with occipital-neuralgia caused by spinal column compression during her fall 6 months ago. He prescribed 100-units of Botox, injected into the frontal, temporal, cervical, occipital, and supraorbital areas of the head. This resolved the headaches for two months. She returned to horseback riding but limited her workouts. She received another dose of Botox three months after the initial treatment and she will continue this treatment with an increasing number of months in between doses. **Uniqueness:** All diagnostic testing was negative for causes of occipital headaches. Pain continued to increase over five months with no medicinal relief. She developed other symptoms including tachycardia due to the severity of pain. This diagnosis was related to an injury that initially had no head or neck pathology. **Conclusions:** Differential diagnosis is important in cases where symptoms do not resolve. Mechanisms of injury may be unassuming, and specialists may be needed to identify conditions not typically encountered in athletic training and sports medicine.

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**Contact Dermatitis And Other Eczema Unspecified Cause In A Female Softball Athlete**

Zgrabik R, Elliott R, Sexton S, Brown CN, Ferrara MS: University of Georgia, Athens, GA, and Sexton Dermatology, Athens, GA

**Background:** A 19-year-old female intercollegiate softball athlete reported to the athletic training staff complaining of dry, red and scaly spots on her arms and legs. She began to notice the multiple flat red areas about two weeks prior because of mild itching. Pain was 0/10 with normal blood pressure, pulse, and temperature. Past medical history indicated no previous skin rashes or allergies. Athlete recently moved into a new house with new roommates. She reported no changes in soaps, detergents, medications, or any exposure to pets. There was no preceding illness but she did present with a sore throat. **Differential Diagnosis:** Contact dermatitis, viral dermatitis, eczema, tinea corporis, pityriasis rosea, psoriasis, syphilis. **Treatment:** Athlete was referred to the team physician who had diagnosed her with an unknown contact dermatitis. She was referred to a dermatologist who ordered a skin biopsy to determine whether the athlete had tinea corporis or pityriasis rosea. The dermatologist thought it was most likely tinea corporis and Lamisil (250 mg) was presumptively prescribed. The skin biopsy was negative for tinea corporis and the athlete was told the cause of her rash was likely pityriasis rosea. However, at three weeks following the biopsy, the rash had not improved and a second biopsy was ordered to rule out psoriasis. The biopsy ruled out psoriasis, but the dermatologist was not able to definitively diagnose the athlete. Prednisone (10mg) was prescribed for the lesions to reduce inflammation. Standard blood analysis was performed with an Antinuclear Antibodies (ANA) test. Two weeks later, all blood test results were normal and the athlete was then referred to another dermatologist for a second opinion. The second dermatologist also ordered blood tests to rule out sexually transmitted infections (STI's) such as syphilis. STI's were negative and the dermatologist decided to treat the skin disorder as eczema of unknown cause. She was prescribed the antibiotic Omnicef (300mg) and two ointments to help treat the symptoms including Calcitriol (3g) which is a vitamin D ointment and Ultravate (.05%) which is a steroid ointment. Because the rash was not definitively diagnosed, the possibility of spreading the unknown condition to her teammates was discussed. The dermatologist was confident that the rash would not spread to other athletes. No one on the team, nor any medical personal working closely with the athlete, ever

contracted the rash. **Uniqueness:** This case proved difficult to definitively diagnose relatively common skin conditions. In the early stages it presented like tinea corporis, then pityriasis rosea; however, when it did not improve it was thought to be psoriasis or possibly an STI. All diseases have been ruled out with a skin biopsy and blood tests but there is still no known cause or definitive diagnosis of the athlete's skin disorder. **Conclusions:** Skin disorders can present in many different fashions. The Athletic Trainer and other clinicians need to not only be familiar with these disorders, but also be aware that patients may present differently despite similar disorders.

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**Proximal & Distal Tibiofibular Instability In A Competitive Cheerleader**

Morin G, Geiger G: Southern Connecticut State University, New Haven, CT

**Background:** This case presents a rare injury involving the proximal and distal tibiofibular joints of a 19 year-old competitive cheerleader. She reported to the athletic training room complaining of acute left lateral knee and ankle pain. The mechanism of injury included a sudden inversion and plantarflexion of her left ankle while her body was moving forward over her ankle during a tumbling run. Her knee was reported to be in partial flexion at the time of injury. Physical assessment noted point tenderness in her distal iliotibial band, the LCL, lateral joint line and around the fibular head. Excessive movement of the proximal fibula was identified during anterior-posterior translation of the fibular head with the knee at 90 degrees flexion. Similar translation of the distal fibula resulted in abnormal movement of the distal tibiofibular joint. Tibiofemoral joint ROM was normal, and she was free from neurological symptoms in her lower extremity. Ligamentous and meniscal special testing were negative except for varus testing, which resulted in lateral knee pain. There is a history of an unrelated ankle sprain to the same ankle one month earlier. **Differential Diagnosis:** Lateral collateral sprain, lateral meniscus tear, Maisonneuve fracture, proximal tibiofibular instability, distal tibiofibular instability. **Treatment:** The patient was referred to the team physician and she later obtained a second opinion with an orthopedic physician near her home. Both physicians diagnosed the condition as proximal and distal tibiofibular joint instability and recommended conservative care. A subsequent MRI demonstrated mild edema at the proximal tibiofibular joint and a partial discoid lateral meniscus. Other knee ligaments were intact. The patient was immobilized for 5 weeks at 0 degrees extension and placed in a NWB condition, except for her treatment sessions. Early rehabilitation activities included passive ROM to prevent tibiofemoral stiffness, patellar glides, anterior/posterior talotibial glides to prevent posterior ankle stiffness, soleus and medial hamstrings stretching, and 4-way SLR's with progressive resistance. After 5 weeks, she was kept PWB for one week. Weightbearing exercises were introduced including double then single leg squats, proprioception exercises and initial gait training. The healing tissue was protected with the use of a Universal Forearm Support (Smith & Nephew Donjoy Inc, Carlsbad, CA ) which was sized for her lower leg, one inch inferior to the fibular head. This support was applied to her proximal tibia with an anterior pull of the strap through the plastic ring over her proximal fibula. Stability of the distal tibiofibular joint was aided with the application of circumferential tape strips to her plantarflexed ankle just proximal to her distal tibiofibular joint. Upon release to FWB, she began a more aggressive therapy program in anticipation of her upcoming national competition. **Uniqueness:** Proximal tibiofibular joint instability is considered a rare injury, and may be misdiagnosed. The injury and its subsequent rehabilitation is confounded by the simultaneous pulls of the biceps femoris on the fibular head, and the peroneal longus muscle on its origin during sudden ankle inversion, accompanied by the static pull of the proximal tibiofibular ligaments. Immobilization of 4-6 weeks is indicated, and care must be taken to prevent the biceps femoris and peroneal longus from applying tension on the fibula during the early healing process. Distal tibiofibular laxity is aggravated by ankle dorsiflexion which causes the talus to separate the fibula from the tibia. **Conclusions**: Proper assessment of inversion ankle sprains must include consideration of the proximal fibula. The biceps femoris and the peroneal longus can combine to cause adverse forces at the proximal tibiofibular joint. Understanding the mechanics of lateral knee muscles is important in the rehabilitation of proximal tibiofibular instability.

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# Free Communications, Oral Presentations: Health Related Outcome Measures

Thursday, June 24, 2010, 8:00AM-9:00AM, Room 203AB, Moderator: Craig Denegar, PhD, ATC, PT

**Athletic Trainer Referral And Taping Patterns Of Soldiers During Basic Combat Training**

Mensch JM, Dompier TP, Carlow A, Williams KW: Department of Physical Education and Athletic Training, University of South Carolina, Columbia, SC, and Experimentation and Analysis Element, Fort Jackson, SC

**Context:** The Department of Defense (DOD) recently estimated that musculoskeletal injuries cost the DOD over $1.5 trillion annually. Soldier visits to Army medical clinics contribute substantially to that burden. **Objective:** The purpose of this program was to determine if athletic trainers (AT) reduced Soldier training days lost from referrals and musculoskeletal injuries. **Design:** Prospective observational. **Setting:** A United States Army Training Center located in the Southeast United States from 2008 to 2009. **Patients or Other Participants:** Male and female Soldiers engaged in BCT who visited the Battalion Aid Station (BAS). **Interventions:** The independent variable was condition. The conditions included the control (no athletic trainer) and two experimental conditions. The experimental conditions were partial integration (PI) and complete integration (CI) of ATs. The main differences included in the CI were regular educational briefings for Soldiers and the limitation of 10 Soldier examinations per morning sick call. **Main Outcome Measures:** Referrals to the Troop Medical Clinic (TMC) and tapings for musculoskeletal injuries were the dependant variables. A referral was defined as any Soldier with a musculoskeletal injury referred to the TMC. A single visit to the TMC was estimated to equal 1-day lost from training. Tapings included any wraps applied with the intent to assist a Soldier in completing a training activity. The absolute risk reduction (ARR) between conditions was applied to estimate Soldier training days saved from reduced referrals. Proportions are reported with 95% confidence intervals (CI). **Results:** There were a total of 2759 visits, 40.4% of which were referred to the TMC. The proportions of musculoskeletal injuries referred were 51.4% (95% CI = 47.8%,55.0%), 38.5% (95% CI = 36.2%,40.8%), and 24.3% (95% CI = 19.8%,29.6%) for the control, PI and CI conditions, respectively. The ARR of the control and PI was 12.9% (95% CI = 8.7%,17.2%), and between the control and CI was 27.1% (95% CI = 20.8%,32.9%). Based on the CI ARR (27.1%) and number of musculoskeletal referrals across all 22 BCT

Battalions (102,500), 27,788 (95% CI = 21,320, 33,723) referrals per year could be averted. Taping practices revealed that there were 992 tapings performed over 495 training days or approximately 2.0 (95% CI = 1.1,2.8) per day. Based on the number of training days per year that ATs would be available to tape across 22 Battalions (5280), potentially 10,560 (95% CI = 5,808, 14,784) Soldiers might complete training activities that might otherwise drop out, assuming all who are taped would complete the activity. **Conclusions:** Implementing half-time ATs at an Army Training Center resulted in reduced referrals and a substantial amount of training activities completed that might otherwise see a Soldier dropping out. Future research should seek to determine what percentages of taped Soldiers actually complete activities.

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**Rasch Calibration Of The Late Life Function And Disability Instrument**

Scott CB, Snook EM: Physical Activity and Behavior Lab, University of Massachusetts, Amherst, Amherst, MA

**Context:** The Late Life Function and Disability Instrument (LL-FDI) was created based on the disablement model to measure function and disability for a variety of disease populations. The LL-FDI measures two components function and disability. The function component consists of lower extremity and upper extremity functional items. The disability component assesses the frequency and limitation of performing social and personal role activities. Recently a short form of the LL-FDI was developed and its psychometric properties have not been adequately addressed. **Objective:** The purpose of the study was to investigate the psychometric properties of the LL-FDI short form using the Rasch Rating scale model. **Design:** One-time observational design. **Setting:** The data were collected from physically active multiple sclerosis patients. **Patients or Other Participants:** A convenient sample of 133 participants with multiple sclerosis volunteer to participate (29 males, 104 females; mean ± SD: age: 51 ± 11 yrs; mean duration since diagnosis: 12 ± 9 yrs; EDSS: 5.5 range 1 - 8.5). **Interventions:** The participants' responses on the LL-FDI short form were calibrated for each component function (15 items), disability frequency (8) and limitation (8) of performing social and personal role activities, separately using the Rasch Rating scale model. Rasch calibrations were performed using Winsteps 3.68. **Main Outcome Measures:** Model-data fit was determined by evaluating the items infit and outfit statistics, which should be between 0.5 and 1.5 for good fit. Person and item separation index and reliabilities were also calculated. Visual inspection of the Wright item-person map was also performed to determine good alignment of item difficulties and participants' ability levels. **Results:** The function component had good model data fit with 11/15 items having acceptable fit statistics. The functional items difficulties ranged from -1.55 to 2.47 logits. The person separation index and reliability were 3.3 and 0.92. The item separation index and reliability was 8.29 and 0.99. Map indicated item person overlap. The frequency component of disability had excellent model data fit (8/8 fit model). Item difficulties ranged from -1.65 to 0.93 logits. Person separation index and reliability were 1.6 and 0.72. Item separation index and reliability were 6.9 and 0.98. The visual inspection indicated acceptable overlap of items and people. The impact of the disability component shows excellent fit (7/8 fit model). Item difficulties ranged from -0.79 to 0.5 logits. Person separation and reliability were 2.2 and 0.83. Item separation and reliability were 3.3 and 0.92. The visual inspection showed poor item spread. **Conclusions:** The psychometric results for the LL-FDI short form indicate that the short form is an adequate measure of function and the disability components are limited. Further investigation and application of this scale in athletic training can provide valuable insight into the disablement model of physically active injuries.

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**Return On Investment Analysis Of The Certified Athletic Trainer-Forward Program**

Dompier TP, Mensch JM, Carlow A, Williams KW: Department of Physical Education and Athletic Training, University of South Carolina, Columbia, SC, and Experimentation and Analysis Element, Fort Jackson, SC

**Context:** Musculoskeletal injuries cost the Department of Defense (DOD) an estimated $1.5 trillion annually. Attrition during Basic Combat Training (BCT) in the United States Army alone costs approximately $250 million annually. The extraordinary costs and detrimental effect on military readiness makes the reduction of attrition during Army BCT a priority. **Objective:** The purpose of this program was to determine the return on investment (ROI) from reduced attrition as a result of the implementation of the Certified Athletic Trainer-Forward program. **Design:** Retrospective. **Setting:** A United States Army Training Center located in the Southeast United States during the 2008 and 2009 fiscal years (October-September). **Patients or Other Participants:** There were 47,866 (62.7%) male and 28,506 (37.3%) female Soldiers who entered BCT. **Interventions:** The independent variable was condition. The conditions included control (no athletic trainer) or the intervention (a half-time athletic trainer [AT]). The ATs performed a variety of functions including but not limited to sick call evaluation and treatment of musculoskeletal injuries, educational and prevention programs, and acute care during training activities. **Main Outcome Measures:** Attrition was the dependant variable. Attrition was defined as any Soldier separated from the Army during BCT for both medical and non-medical reasons. Cases were stratified by gender and type. The absolute risk reduction (ARR) was calculated and used to estimate the number of separations prevented (ARR*Soldiers at risk) in the intervention group. Training costs saved were determined by multiplying the number of separations prevented by the cost to train a single Soldier ($29,800). The ROI was calculated by subtracting the program costs ($2,230,292) from the estimated training costs saved and then dividing by the program costs. All estimates were calculated with 95% confidence intervals (CI). **Results:** Overall attrition in the control group was 7.43% (95% CI = 7.06%,7.82%) and 6.08% (95% CI = 5.89%,6.27%) in the intervention group for an ARR of 1.35% (95% CI = 0.94%,1.78%). The overall training costs saved from reduced attrition in the intervention group was $23,367,596 (95% CI = $16,449,600, $30,813,200). The overall ROI was $9.48 (95% CI = $6.38, $12.82) for each $1 spent on the program. Overall female attrition was 10.77% (95% CI = 10.07%,11.51%) in the control group and 9.18% (95% CI = 8.80%,9.57%) in the intervention group. Overall male attrition was 5.35% (95% CI = 4.95%,5.78%) in the control group and 4.27% (95% CI = 4.07%,4.48%) in the intervention group. **Conclusions:** Implementing half-time ATs at the Battalion level at an Army Training Center resulted in a positive ROI from training costs saved as a result of reduced Soldier attrition. Future research should examine a full-time AT model and the efficacy of ATs at other Army training sites.

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**Health-Related Quality Of Life Following Sport-Related Concussion In Adolescent Athletes**

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

**Context:** Sport-related concussion (SRC) may impact health-related quality of life (HRQOL), a concept that encompasses physical, psychological, and social domains. In adolescents, lower HRQOL can result in increased school absences and decreased academic performance. Understanding the impact of SRC on HRQOL may help identify

areas for improving concussion management. **Objective:** To investigate how general, fatigue-specific, and headache-specific HRQOL is impacted by SRC. **Design:** Pre-post, repeated measures. **Setting:** High school athletic facilities. **Patients or Other Participants:** 44 adolescent athletes who sustained a SRC diagnosed by their athletic trainer (43 males, 1 female, age=15.2±1.0 years, grade=10.1±1.0 level). **Interventions:** Participants completed the Pediatric Quality of Life Inventory (PedsQL), PedsQL Multidimensional Fatigue Scale (MFS), and Headache Impact Test (HIT-6) during a preseason baseline (BL) and on days 3 (D3), 10 (D10) and 30 (D30) post-concussion. All measures have published reliability and validity. The independent variable was day. Generalized estimating equations analysis with an inverse Gaussian distribution was used following reciprocal transformation of dependent variables. Least square differences pairwise comparisons were used to determine differences ($p<.05$, two-tailed) across the 4 days for each dependent variable. Repeated measures are assumed to have a first-order autoregressive relationship. **Main Outcome Measures:** Dependent variables included: 4 subscale scores of the PedsQL [physical (PF), emotional (EF), social (SOF), and school (SCF) functioning], 3 subscale scores of the MFS [general (GF), sleep (SLF), and cognitive (CF) fatigue], and the HIT-6 total score. Higher scores on the HIT-6 and lower scores on the PedsQL and MFS indicate lower HRQOL. **Results:** On D3 concussed athletes reported significantly lower HRQOL compared to BL for the PF ($p<.001$, BL=90.3±10.7, D3=77.2±18.2), SLF ($p=.039$, BL= 68.8±20.1, D3=65.7±21.3), CF ($p=.031$, BL=88.2±16.1, D3=71.7±19.3) and HIT-6 ($p<.001$, BL=46.2±6.9, D3=51.9±7.6); the remaining subscales revealed no significant differences. By D10 all scores returned to BL and two subscales (EF, SCF) demonstrated significant improvements ($p<.05$) from BL. At D30 HRQOL was significantly higher compared to BL for PF ($p=.007$, BL=90.3±10.7, D30=96.9±7.4), EF ($p<.001$, BL=89.8±11.1, D30=98.7±5.9), SOF ($p<.001$, BL=91.9±11.1, D30=98.9±3.1), SCF ($p<.001$, BL=82.7±14.8, D30=94.9±9.3), GF ($p=.019$, BL=84.0±15.7, D30=95.4±10.6), SLF ($p<.001$, BL=68.8±20.1, D30=91.4±16.1) and HIT-6 ($p<.001$, BL=46.2±6.9, D30=41.0±6.8). Concussed athletes returned to play 13.1±5.4 days post-concussion. **Conclusions:** Athletes sustaining a SRC demonstrated lower HRQOL, related to physical functioning, sleep fatigue, cognitive fatigue, and the impact of headache, in the immediate days post-injury. These findings corroborate reports of the symptoms experienced acutely post-concussion and align with a time when athletes are often restricted from participating in physical and cognitive activities. Clinicians should address these areas when providing home instructions to patients. HRQOL deficits generally improved by D10, which may reflect when most athletes were cleared to return-to-play. Interestingly HRQOL tended to be significantly higher at D30 compared to BL, which may be related to sport participation. *Funding provided by a grant from the National Headache Foundation.*

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# Free Communications, Oral Presentations: Health Related Outcome Measures Cont.

Thursday, June 24, 2010, 9:15AM-10:15AM, Room 203AB, Moderator: Craig Denegar, PhD, ATC, PT

### Health-Related Quality Of Life: Gender Differences Between Adolescent Athletes

Parsons JT, Lam KC, Bay RC, Mathieson K, Snyder AR, Valovich McLeod TC: A.T. Still University, Mesa, AZ

**Context:** Patient-based outcome measures are important for assessing health-related quality of life (HRQOL) and providing patient-centered, whole person healthcare. Previous work using generic measures of HRQOL identified that female adolescent athletes tend to report lower HRQOL and more symptoms than males. However, it is unknown whether condition-specific outcomes measures detect similar gender differences. **Objective:** To identify gender differences in fatigue-specific, headache-specific, and generic HRQOL and to assess the relationship between HRQOL and reported symptoms. **Design:** Cross-sectional. **Setting:** Athletic facilities. **Patients or Other Participants:** Convenience sample of female (n=242, age=15.2±1.5 years, grade=10.2±1.1) and male (n=1310, age=15.3±1.9 years, grade=10.2±1.1) adolescent interscholastic athletes. **Interventions:** Gender was the independent variable. Subjects completed the Pediatric Quality of Life Inventory (PedsQL), PedsQL Multidimensional Fatigue Scale (MFS), Headache Impact Test (HIT-6), and a graded symptom scale (GSS) in one testing session during their preseason. Internal consistency for the PedsQL scores ranges from .68-.88, and the MFS reliability is reportedly .90. Test-retest reliability for the HIT-6 has been reported as .70 and the GSS intraclass correlation coefficient is reportedly .88. **Main Outcome Measures:** Dependent variables included the scores for the 4 PedsQL subscales [physical (PF), emotional (EF), social (SOF), school (SCF) functioning], the 3 MFS subscales [general (GF), sleep (SLF), cognitive (CF) fatigue], the HIT-6, and the GSS total symptoms endorsed (TSE). Lower scores on the PedsQL and MFS and higher scores on the HIT-6 indicate diminished HRQOL. Higher scores on the TSE indicate more symptoms endorsed. The Kolmogorov-Smirnov test ($p<0.05$) was used to determine data normality. Gender differences were assessed with separate Mann-Whitney U tests ($p<0.05$) across all dependent variables and reported as median [interquartile range (IQR): $25^{th}$, $75^{th}$]. Spearman's rho correlations were run between significantly different HRQOL subscales and TSE scores. Analyses were exploratory and no adjustments for multiplicity were made. **Results:** Female adolescent athletes demonstrated significantly lower scores on the EF subscale [$p=0.035$: females=90.0(IQR= 80.0, 100.0); males=95.0(IQR=80.0, 100.0)] and reported higher scores on the TSE [$p=0.007$: females=6.0(IQR=1.0, 11.0); males=4.0(IQR=1.0, 9.0)]. There were no other significant gender differences for the remaining HRQOL subscales ($p>0.05$). Moderate (-.57) and fair (-.47) correlations existed between the EF subscale and TSE scores in females and males, respectively. **Conclusions:** Although there were no reported gender differences in fatigue-specific and headache-specific HRQOL, our results suggest that female adolescent athletes have diminished emotional HRQOL, as measured with the PedsQL, when compared to male adolescent athletes. This difference may be related to the higher number of symptoms reported by the female adolescent athletes. However, it remains unclear how factors including injury, type of injury, and time-to-recovery impact HRQOL in female and male adolescent athletes.

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### Readability Statistics And The Appropriateness Of Commonly Used Region Specific Outcomes Surveys

Ragan BG, Dompier TP: Measuremental LLC, Buffalo, NY, and University of South Carolina, Columbia, SC

**Context:** There is a current need for outcomes based research to support evidence based athletic training practices. Few region specific outcomes instruments have been developed and psychometrically tested with highly functioning

patients in mind. Even fewer region specific instruments have been developed with pediatric populations in mind. Readability is often overlooked, but is vitally important for outcomes instruments to be valid in pediatric patients. **Objective:** The purpose of this study was to examine the readability statistics of three commonly reported region specific outcomes instruments. **Design:** Descriptive. **Setting:** The setting was a research laboratory at a Southeast university. **Patients or Other Participants:** This study evaluated the readability statistics of existing outcomes instruments using computer software (Microsoft Word, Microsoft, Seattle, WA) to calculate the Flesch Reading Ease (FRE) and Flesch-Kincaid Grade Level (FKGL). The FRE can be interpreted as 70-100 = Easy, 60-69 = Standard (eighth & ninth grade), 30-59 = Difficult, and 0-29 = Very Confusing. The instruments examined were the Disabilities of the Arm, Shoulder and Hand (DASH), Foot and Ankle Ability Measure and Sport Subscale (FAAM-SS), and the Knee injury and Osteoarthritis Outcome Score (KOOS). **Data Collection and Analysis:** Individual sentences and item statements from each original instrument were copied directly into separate documents and evaluated individually for FRE and FKGL. The ranges of scores are provided along with means with standard deviations (SD) that were calculated where available. Ideally, FKGL should not exceed an 8$^{th}$ grade reading level for high school students and lower for younger populations. **Results:** The instructions on the DASH ranged in FRE and FKGL from 37.5 to 69.9 (m=48.3±13.8) and 6.7 to 12.8 (m=10.7±2.5), respectively. DASH items were much more variable and ranged from 41.5 to 100.0 in FRE and 0.0 to 12.7 in FKGL. The instructions on the FAAM had a FRE of 53.9 and FKGL of 10.4. The last items on the FAAM and sport subscale portion asking the patient to provide a score between 0 and 100 of their current level of function has an FRE of 20.5 and FKGL of 22.0. Items on FAAM-SS ranged between 18.9 and 100 for FRE and 0 and 12.6 for FKGL. The instructions on the KOOS had appropriate readability statistics and only 3 items had FKGL scores exceeding 8.0. **Conclusions:** The DASH and FAAM lack appropriate readability statistics for use in pediatric populations while the KOOS has mostly appropriate readability statistics. Future research should seek to psychometrically evaluate the KOOS for use in highly functioning physically active populations and additional outcomes instruments should be evaluated psychometrically and for readability before use in pediatric populations.

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**A Comparison Of Clinician-Rated And Patient-Rated Health-Related Quality Of Life Following Sport-Related Musculoskeletal Injury**

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

**Context:** Health-related quality of life (HRQOL), an important patient-oriented outcome, provides an assessment of overall health status. Widespread use of patient self-reported HRQOL is uncommon in athletic training. HRQOL is typically evaluated through the use of patient self-report scales, although there are instruments that assess health status from the clinician's perspective. Currently, it is unknown whether clinician ratings of HRQOL approximate patient ratings. **Objective:** To determine the association between clinician-rated [Athletic Training Outcomes Instrument (ATOI)] and patient-rated [Medical Outcomes Short Form (SF-36) and Pediatric Outcomes Data Collection Instrument (PODCI)] HRQOL. **Design:** Cross-sectional. **Setting:** Athletic training facilities. **Patients or Other Participants:** Convenience sample of injured adolescent athletes (n=50 age=15.7±1.2) participating in interscholastic athletics and their respective athletic trainers (n=10, age= 24.9±3.7, experience ≤ 10 years). **Interventions:** Injured athletes completed a health status questionnaire, SF-36, and PODCI on day 3 post-injury (D3) and at return-to-play or day 30 (D30) post-injury. The injured athlete's athletic trainer completed the ATOI at D3 and D30 as well. Reliability of the SF-36 subscales in the general population is reported as .84-.95 and PODCI subscale reliability coefficients range from .76-.97. Preliminary findings of the ATOI summary score in our sample demonstrated excellent internal consistency at D3 (Chronbach's Alpha = .92) and D30 (Chronbach's Alpha = .97). Pearson Correlation Coefficients (r) compared the D3 and D30 ATOI summary score to the D3 and D30 SF-36 physical composite score (PCS), SF-36 mental composite score (MCS), and PODCI global score, respectively. Higher SF-36, PODCI, and ATOI scores indicate better HRQOL, although they use different scoring schemes. **Main Outcome Measures:** We calculated an ATOI summary score by summing the responses of the 12 current status ATOI questions. Dependent variables included the clinician-evaluated ATOI summary score and 3 patient-evaluated scores: PCS, MCS and PODCI global score. **Results:** Clinicians and patients rated HRQOL differently on D3 (Clinician: ATOI=32.5±8.6; Patient: PCS=39.0±8.4, MCS=48.9±10.7, PODCI= 15.0±17.7) as indicated by low correlations between the ATOI and the PCS (r=.053), MCS (r=.051), and PODCI (r=.109). Clinicians and patients rated physical and global HRQOL more similarly at D30 (Clinician: ATOI=46.3±10.3; Patient: PCS=48.8±9.7, MCS=50.4±13.1, PODCI= 31.7±19.7) as indicated by strong positive correlations between the ATOI and the PCS (r=.805) and PODCI global score (r=.659). There was no correlation between clinician and patient ratings of MCS (r=-.056) at D30. **Conclusions:** Evaluation of HRQOL by clinicians does not correlate well with patient-oriented measures of health status in the early stages of injury. As injury management progresses, clinicians appear better able to evaluate HRQOL. Interestingly, clinicians poorly rated the mental components of patient health status at both the early and late stages of injury. Our results suggest that meaningful evaluation of HRQOL be made by patients through the use of patient self-report outcome measures.

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**Multiple Baseline Concussion Neurocognitive Assessments Are Needed In Interscholastic Athletes**

Broglio SP, Macciocchi SN: University of Illinois at Urbana-Champaign, Urbana, IL, and Shepherd Center, Atlanta GA

**Context**: Baseline testing for concussive injuries has been recommended by several expert panels and medical organizations. In many settings, these tests are administered at the beginning of an athlete's academic career. It is unknown if a single test administration can provide the reliability necessary for clinical interpretation beyond the current playing season. **Objective**: To establish if a single neurocognitive assessment is sufficient for concussion management across an academic career. **Design**: Repeated measures. **Setting**: High school computer laboratory. **Participants**: Interscholastic football athletes [N=31, 16.4(±0.5) years, height 181.0(±6.0) cm, mass 88.9(±18.1)kg, 10.1(±0.5) years of education, and 0.5(±0.8) previously diagnosed concussions]. **Interventions**: Each athlete twice completed the ImPACT neurocognitive assessment for concussion on an annual basis prior to the competitive season. Testing sessions were separated by 353.2(±87.3) days. **Main Outcome Measures**: ImPACT scores (verbal memory, visual memory, visual motor speed reaction time, impulse control, and total symptom reports were evaluated using intraclass correlations (ICC 2,1). Reliable change indices were applied to output scores to identify athletes with notable performance changes between sessions. **Results**: Reliability (ICC: 95% confidence interval) for the ImPACT output scores were calculated at: verbal memory (.38: .04 to .64), visual

memory (.29: -.07 to .58), visual motor speed (.49: .16 to .71), reaction time (.23: -.13 to .54), impulse control (.39: .05 to .65), and total symptoms (.46: .13 to .70). Notable performance changes were noted in 71% of the sample with 45% showing a performance decline and while 55% of the athletes improved over time. **Conclusions**: The athletes in this sample demonstrated variable performance across the two testing sessions. Not all athletes demonstrated change on all variables, but the results suggest that a single neurocognitive baseline measure may not be sufficient for an athletes playing career. Annual or multiple baseline assessments should be considered.

## Free Communications, Case Reports: Non-Orthopedic

Thursday, June 24, 2010, 10:30AM-11:30AM, Room 203AB, Moderator: Andrew Reisman, MD, ATC, FAAFP

### Recalcitrant Supraventricular Tachycardia In A 26-Year-Old Professional Freestyle BMX Rider

Oller DM: Seton Hall University, South Orange, NJ

**Background:** This report deals with a 26-year-old, male, professional, freestyle BMX rider (weight 63.5 kg, height 175.2 cm) who underwent a third radiofrequency catheter ablation, secondary to the presence of poorly controlled supraventricular tachycardia (SVT). His pediatric cardiopulmonary medical history is extensive and includes a ventricular septal defect (VSD) status-post repair at age 18 months. The athlete underwent an initial ablation at age 19 years following the onset of SVT, and a second ablation at age 25 after SVT reemerged. When SVT occurred two weeks after the second ablation, the athlete was prescribed the beta-blocker Atenolol (25 mg OD), which elicited dizziness, lightheadedness, and fatigue when riding. As SVT frequency increased to approximately once weekly, the anti-arrhythmic Flecainide (50 mg BID) was additionally prescribed. Ultimately, SVT occurred nearly each time the athlete rode, with symptoms including lightheadedness and dyspnea, and the medication side effects negatively affected his performance and safety. His resting heart rate was 36 BPM, and ranged from 150 to 220 BPM during SVT. Conservative interventions, such as performing a Valsalva maneuver, were rarely effective, and the athlete often resisted hospital emergency departments for adenosine intervention. The athlete's AT referred him to an electrophysiologist, as his then-current cardiologist offered no other treatment options. **Differential Diagnosis**: Supraventricular tachycardia, atrial fibrillation, or atrial flutter. **Treatment:** Upon a thorough history, physical examination, ECG, and the utilization of an ambulatory ECG monitor while riding, the electrophysiologist concurred with the previous SVT diagnosis, and believed a third ablation presented a 50% chance for success. Both cardiac medications were discontinued prior to hospital admission. Pre-operatively, an MRI and a transesophageal echocardiogram were performed. An electrophysiology study immediately preceding the ablation found SVT with a single discernible mechanism involving musculature bridging the right atrium and coronary sinus, and radiofrequency energy terminated the tachycardia. The electrophysiology study and ablation were approximately 8 hours in duration. The athlete's hospital stay totaled 3.5 days without incident, and no limitations were placed on physical activity following the healing of the catheter sites at his bilateral groins. As of 15 months post-ablation, the athlete has not experienced SVT. **Uniqueness:** The effectiveness for catheter ablation is greater than 86%. It is hypothesized that SVT originated from scar tissue cause by the VSD repair. Aside from the initial incident, SVT only occurred when the athlete rode, which may be related to sport-specific physiological and psychological demands. He strictly avoided ingesting all forms of stimulants, as the cardiologist did not address nutritional concerns, requiring the athlete to learn via trial-and-error. The athlete continued to ride regularly, though for shorter durations than his peers, and competed 6 weeks after the second ablation. In the 16 months between the second and third ablations, the athlete experienced 4 serious BMX falls, which he attributes to the medication side effects. The electrophysiologist did not restrict the athlete's physical activity, as SVT is rarely life-threatening. Against medical advisement, the athlete learned to break the SVT rhythm by riding intensely to increase his heart rate even greater. **Conclusions:** A comprehensive past medical history, social history, and physical examination are necessary for the delivery of quality and effective healthcare. It is paramount that ATs recognize their role as athlete advocates, particularly in cases such as this where another treating clinician may not recognize the ways in which a particular diagnosis and subsequent pharmacological intervention affect athletic participation and injury risk. Should a clinician be unfamiliar with a sport's demands, the AT should take initiatives to educate said clinician. ATs must have a strong understanding of how SVT affects athletic participation and when it is necessary to seek emergency medical services.

### Parsonage Turner Syndrome In A Collegiate Softball Athlete

Peterson TD: Barton College, Wilson, NC, and University of New England, Biddeford, ME

**Background:** An 18 year old female right handed softball player was an outfielder for a NCAA Division II collegiate team. Her initial complaint was that she woke up with general pain as well as some numbness and tingling in her left shoulder (non-throwing arm), without any known mechanism of injury. Initial evaluation showed her range of motion in all directions was limited by about 15-20 degrees, she was tender to palpation throughout entire shoulder with the most pain over the bicipital groove, and she was positive with all impingement and biceps tendonitis special tests. She was allowed to play in the game that day with no noticeable or reported problems, and no additional injury. The following day she came in to athletic training room in severe pain and had numbness and tingling that went into her fingers. Her range of motion had drastically decreased with active flexion and abduction limited to about 60 degrees. She was extremely tender with palpation over the bicipital groove, coracoid process, and in the axillary region, and did not want the athletic trainer to touch anywhere in those areas. She was unable to perform any special test due to pain. Throughout the next couple of days her pain levels increased, her range of motion decreased, and she lost most function with her left arm. **Differential Diagnosis:** Impingement, Biceps Tendon Strain, Biceps Tendon Rupture, Brachial Plexus Neuropathy, and/or Parsonage Turner Syndrome. **Treatment:** Athlete was placed in a sling and iced as often as possible. She was referred through the team physician for an MRI, and referred on to a neurologist

for a nerve conduction test and EMG, which she had done on two separate occasions about two weeks apart. She was kept as comfortable as possible through rest, ice, and NSAIDs. Once her motion began to return, a rehabilitation program was started that worked on reaching her full range of motion, as well as strengthening the entire shoulder complex. **Uniqueness:** Parsonage Turner Syndrome is a rare condition that ultimately has no known cause. It has been associated with viral infections, vaccinations, pregnancy, and systemic illnesses including lyme disease, lupus, and diabetes. In this case it was assumed the athlete may have developed Parsonage Turner due to a virus, as she did not have any other potential causes. In numbers that have actually been reported it tends to affect males more often than females and occurs in less than 2 people for every 100,000. **Conclusions:** Parsonage Turner Syndrome and other unique diseases are conditions athletic trainers should be aware of. While it is not possible to become an expert on every potential disease, athletic trainers should be able to recognize signs and symptoms that are not common with everyday injuries and understand that a referral is necessary to accurately diagnose these conditions.

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**A Case Of Reflex Neurovascular Dystrophy In A 13 Y.O. Girls' Soccer Player**

Wuyscik JM: UPMC Sports Medicine, Pittsburgh, PA

**Background:** Athlete initially presented with right hip pain. She had no recollection of a mechanism for her injury/pain. No palpable tenderness and no painful "popping/clicking" were present. Her pain was a 5/6 of 10. She had full passive, active and resistive ROM, with only mild discomfort on resistive hip flexion and abduction. Athlete had discomfort with the Hip Scouring Test. She began walking with an antalgic gait and was unable to run without pain. Initial treatment involved no practice for five days, icing, and painfree active ROM exercises. Upon re-evaluation the following week, the athlete was "feeling much better". She had full AROM and RROM with minimal discomfort. The Hip Scouring Test was not as painful. She exhibited a normal gait and her pain with running decreased to 2 of 10. She continued with ROM exercises. The athlete progressed well and returned to full practice by the end of the week. Her pain remained at 2 of 10 maximum and she was fully functional with a normal gait pattern. Athlete was cleared to return to full activity at the beginning of the following week. By the end of the week, the athlete admitted her pain had increased to 8 of 10 with running. The athlete was then referred to a physician. **Differential Diagnosis:** Hip sprain/strain, avulsion fracture, labral tear, femoral head/neck fracture. **Treatment:** Athlete was evaluated by a physician and received x-rays and an MRI. The x-rays were normal; however, the MRI indicated two labral tears. The physician did not feel the labral tears warranted surgery at that time. The athlete was held out of soccer and attended rehabilitation 2-3 times a week for approximately 6 weeks. At the end of the season I was informed that the athlete had been in and out of the hospital twice in the last several weeks due to illness. She was currently in the hospital again due to complaints of severe pain, numbness and tingling in her lower extremities bilaterally. The athlete received MRIs, CT scans, nerve conduction tests, and blood work in an attempt to reach a diagnosis. The athlete's care was transferred to a pediatric rheumatologist at Children's Hospital and she was finally diagnosed with Reflex Neurovascular Dystrophy. The athlete was unable to attend school at this time and she began outpatient therapy for approximately one month and was then admitted to an inpatient program for two weeks. During her inpatient treatment, the athlete received 8 hours of therapy a day along with tutoring for school and counseling. The athlete has had several relapses since her discharge, and she has returned to therapy. She returned to soccer this past Fall but was unable to finish the season due to her hip pain returning. She will be having surgery next month to repair the two labral tears in her hip. **Uniqueness:** This case is unique because Reflex Neurovascular Dystrophy is a relatively rare and frequently misdiagnosed condition. Treating athletes with this condition is challenging due to the fact that their injuries/illnesses can lead to a flair up of their condition which can make treating their injuries difficult. **Conclusions:** More research needs to be done with regards to RND. Children with this condition, in most cases, are not receiving a proper diagnosis for months or are being misdiagnosed which delays proper treatment and recovery. If more ATs were familiar with this condition, the athlete's time from onset of symptoms to diagnosis by a physician would be dramatically decreased.

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**Recurrent Exertional Rhabdomyolysis In An Intercollegiate Athlete With SSRI**

Newsham KR: Saint Louis University, St. Louis, MO

**Background:** An 18 year-old female intercollegiate volleyball player withdrew from the third session on first day of preseason practice in which callisthenic type exercises were emphasized. She reported nausea, lightheadedness, fatigue, weakness and muscle soreness to the athletic trainer (AT). The athlete was removed from practice to an air-conditioned athletic training facility for more aggressive cooling and rehydration with an electrolyte replacement drink. The patient's symptoms worsened to include photophobia, chest tightness, increasing confusion, and generalized, severe muscle soreness (reported as 9 on a scale of 0-10). The athlete claimed to be well conditioned for sport and reported no history of exertional heat illness or sickle cell trait. Medical history was positive for bronchial asthma and anxiety (medications: montelukast sodium; mometasone furoate inhalation powder and paroxetine hydrochloride, respectively). **Differential Diagnosis:** Dehydration; heat exhaustion; viral infection; exertional rhabdomyolysis; hypoglycemia; asthma; adverse reaction to medication; delayed onset muscle soreness. **Treatment:** The athlete was transported to a local emergency department via EMS where three liters of intravenous fluid were administered. Blood and urine samples were not obtained until after administration of IV fluids. A complete blood count (CBC) indicated elevated creatine phosphokinase (CPK) levels (1691 U/L), slightly elevated liver enzymes (SGOT: 77; SGPT: 46), and slightly lowered red blood cells and glucose (RBC: 3.90; Glc: 73 mg/dL), other measures were WNL. Urinalysis indicated golden-yellow urine with elevated keytones (15 mg/dL) and blood (moderate); other measures were WNL including specific gravity (1.015g/ml). Symptoms, other than generalized, severe muscle soreness and fatigue, resolved in the ED and the athlete was released to the care of the team physician with a diagnosis of mild exertional rhabdomyolysis. Recovery was supervised by the AT, with attention to hydration status and muscle soreness, up to and after her gradual return to activity at 6 days post injury. The athlete reported no additional symptoms until the following preseason when she reported generalized, severe muscle soreness after two days of volleyball practice that emphasized plyometric drills. The athlete was immediately removed from activity and referred to the team physician for diagnostic testing which identified mildly elevated CPK levels (950 U/L). Treatment included

rehydration and refraining from physical activity until muscle soreness subsided (3 days); recovery was without incident. The athlete had a third episode of mild exertional rhabdomyolysis during the preseason during her third year; however, the rhabdomyolysis was considered to be minimal and symptoms resolved without incident (2 days). **Uniqueness:** This athlete had three episodes of rhabdomyolysis over three years, though in progressively decreasing severity. The initial episode involved elevated CPK levels that were significantly lower than those reported the literature, however, the muscle soreness was more severe and widespread than reported in those cases. The prevalence of exertional rhabdomyolysis has been reported in a range of 3-43%, though it is often reported in case reports of a "rare condition". Two reports of recurrent rhabdomyolysis in athletes were found in the literature, with carnitine palmitoyltransferase II deficiency identified as an underlying condition. This metabolic disorder was not identified in our patient. Our patient had no reported history of exertional rhabdomyolysis, but had several known risk factors including: prolonged intense exercise; inadequate fluid intake; inadequate food intake; status asthmaticus; and SSRI medications. **Conclusions:** Individuals engaging in prolonged intense exercise, particularly with dehydration, are at increased risk for exertional rhabdomyolysis. A higher index of suspicion is warranted for individuals with additional risk factors, including SSRI medications and other drugs. A key characteristic of exertional rhabdomyolysis in this case was disproportionate muscle soreness. Early recognition and treatment of exertional rhabdomyolysis is critical as acute renal failure is a potential sequelae.

## Free Communications, Case Reports: Injuries in Football

Thursday, June 24, 2010, 4:30PM-5:45PM, Room 203AB, Moderator: Rick Burkholder, MS, ATC

### Thigh Injury In An Intercollegiate Football Player

Heinerichs S, Jimenez C, Seymour P: West Chester University, West Chester, PA, and University of Pennsylvania Hospital, Philadelphia, PA

**Background:** The athlete is a 22-year-old male wide receiver for a division II intercollegiate football team (height – 175 cm; weight – 79.5 kg). After a pre-season practice he reported to the athletic training room complaining of right thigh pain. The subject had no prior history of thigh pathology. The athlete did not recall a specific incident but complained of pain in his anterior thigh following sustained running throughout practice. Upon examination he presented with tenderness in the proximal middle third of his right anterior thigh with no obvious deformity. Manual muscle tests revealed 4/5 for hip flexion and knee extension. There was full sensory and motor function of the lower extremity. The treatment plan (weeks 0-2) included: cold modalities, strengthening and pain-free active range of motion. Range of motion for knee flexion was monitored daily through goniometric measurement and no deficits were noted. The individual did not experience any increases in pain over this time period and continued to perform activities of daily living. Three weeks post injury a palpable mass was detected in the proximal middle third of his anterior thigh. **Differential Diagnosis:** Rectus femoris indirect head strain, rectus femoris strain, myositis ossificans, tumor. **Treatment:** The team physician evaluated the athlete three weeks post injury and ordered x-rays to rule out myositis ossificans. X-rays were negative and the athlete continued a supervised thigh rehabilitation protocol focusing on strengthening the quadriceps and active pain free stretching. A running protocol was added to the program at week 6; however the athlete was unable to achieve 65% of a maximum sprint without pain. Seven weeks post injury the palpable mass had dissipated and a divot was present in the proximal middle third of the anterior thigh. The team physician re-examined the athlete and ordered a MRI to evaluate the integrity of the muscle. The MRI revealed an incomplete tear to the rectus femoris muscle and specifically a deep intramuscular lesion located within the belly of the rectus femoris muscle. Following the MRI, and a review of literature the treatment protocol was changed. The athlete was not permitted to run until he had full, pain free passive range of motion of the quadriceps. He has continued to perform strengthening exercises, as tolerated, for the lower extremity focusing on the thigh musculature. **Uniqueness:** Quadriceps strains are common injuries in the athletic population. Most are non disruptive in nature, occurring at the musculo-tendonous junction from the proximal or distal attachment, and resolve over time. The origin of the rectus femoris muscle consists of a direct and indirect head. The tendon of the indirect head is unique in that it continues into the proximal muscle belly of the rectus femoris, thus creating an intramuscular tendon within the mid substance of the rectus femoris muscle. This tendon may be injured during typical quadriceps strain mechanisms and require a longer recovery because both muscle and tendonous tissue is affected compared to isolated muscular strains. **Conclusions:** Athletic trainers should be aware of the unique anatomy of the indirect head of the rectus femoris. Injuries to this portion of the muscle (proximal 1/3) may take longer to recover due to the presence of an intramuscular tendon and subsequent tendon injury. Individuals who do not respond to conservative treatment may require MR imaging to properly diagnosis this injury. Athletic trainers should expect these injuries to take longer to heal than quadriceps strains which involve only muscular tissue.

### Spontaneous Avulsion Fracture Of The Tibial Tuberosity In Male Adolescent Football Player

Waters C, Butterfield TA: University of Kentucky, Lexington, KY

**Background:** A 14 year old male adolescent middle school football player was participating in conditioning exercises on the second day of football tryouts, when he suddenly fell to the ground while sprinting straight ahead on a track. The athlete denied any mis-step, tripping, or any type of contact. He reported hearing and feeling a "pop", described his leg as suddenly "snapping back", and conveyed a significant amount of pain (10/10) localized to the anterior aspect of the right knee. He reported no prior history of knee injury, except for previously diagnosed Osgood-Schlatter Syndrome (OSS). The athlete was found sitting up-right on the ground with affected leg in extension in front of his body, and was unwilling, and unable to move the limb. Upon observation/palpation, slight swelling and abnormalities of the patella, patellar tendon, and tibial tuberosity were detected. The patella was extremely hypermobile and when he was asked to perform a quadriceps contraction the patella appeared to translate more superiorly compared to the patella of the contralateral limb. Ligamentous tests where not performed due to the level of pain reported and the possibility of fracture. **Differential Diagnosis:** Tibial tuberosity avulsion fracture, patellar tendon rupture, proximal tibial epiphyseal fracture. **Treatment:** The athlete's right leg was placed in a vacuum splint in extension with ice, and he was transported to the emergency room by

private vehicle, where x-rays revealed an unstable avulsion fracture of the right tibial tuberosity. His right leg was immobilized in full extension and he was given crutches for non-weight bearing ambulation. Six days following the injury, open reduction and internal fixation of the right tibial tuberosity was performed, with examination via fluoroscope to demonstrate the stability of the fragment. The right leg was braced and locked at 0° and the athlete was permitted weight bearing (WB) as tolerated with crutches. Three weeks following surgery, he progressed to full WB with brace unlocked at 0-60° flexion, and began range of motion (ROM) exercises, and strengthening with a focus on eccentrics and motor control. Eight weeks following the initial visit he demonstrated full ROM. The concentration remained on lower extremity eccentrics, with progression to stairs and steps-ups/downs. Twelve weeks post injury he began running, jumping, and agility drills. The athlete has since been cleared to return to basketball in January 2010. **Uniqueness:** A review of literature reports tibial tuberosity avulsion fractures to be extremely uncommon, and the particular flexion-avulsion mechanism of injury described here is very rare. Adolescent males between the ages of 11-16 years are the predominate population to suffer this injury with jumping being the most frequently reported activity/mechanism. A strong eccentric contraction of the quadriceps muscle produces this type of fracture, and OSS may be a predisposing factor. Patients that have sustained this injury are reported to have well-developed musculature and greater muscular strength compared to their male peers. Although this particular athlete meets these criteria, the mechanism by which he sustained his injury was uncommon. **Conclusions:** Although tibial tuberosity avulsion fractures are rare, OSS is commonly reported in adolescents who participate in sporting activities and may be a contributing factor to the injury described here. Those affected often continue participating based on pain tolerance. In this case, however, there was no report of significant knee pain prior to the injury. Therefore, clinicians should exercise caution when allowing children with OSS to continue participating in sports. In the absence of pain, criteria for play should include the degree of OSS, the age and build of the athlete, and the type of activity involved.

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**Acute Fibular Bowing With Traumatic Tibia Fracture In High School Quarterback**

Tarrant A: Texas Wesleyan University, Fort Worth, TX

**Background:** A 16-year-old, 5'11", 140 lb quarterback with no remarkable history of injury to the lower leg or bone disease sustained a transverse fracture of the right mid-tibial shaft that resulted in acute plastic fibular bowing. The patient stated that he ran to the right and after his cleat caught into the ground of a wet grass field, fell over his teammate. On-field examination revealed a medial bulge on the mid-shaft of the tibia and subsequent lateral positioning of the distal aspect of the lower leg. Initial pain was recorded as 8/10, followed by 3/10 one minute post trauma. Light palpation of the medial bump increased pain, and distal stability was compromised. No remarkable deficits were found in the patient's neuro-vascular examination. The patient was vacuum splinted and placed on a spine board for additional support while being taken by ambulance to the hospital. Once at hospital, X-rays revealed a transverse tibial fracture with plastic fibular bowing. The patient was taken into surgery five hours post initial trauma where internal fixation comprising of a rod and four screws were used to reset and stabilize the tibial fracture. Contrary to expectations of needing to fracture the fibula, it returned to proper anatomic contour when the tibia was reset. No injury was sustained to surrounding, proximal or distal structures. **Differential Diagnosis:** Acute tibial fracture, acute traumatic tibial contusion, acute compartment syndrome. **Treatment:** The patient received permanent internal fixation (two screws distal/proximal and a medullary rod) to stabilize the tibia fracture. Contrary to the suspected need to fracture the fibula in order to position correctly, stabilization of the tibia resulted in the fibula straightening on its own. The patient was placed in a walking boot and crutches for six weeks (non-weight bearing), followed by gradual return to full weight bearing status. The patient is expected to make full recovery and full return to play just as in a typical tibial fracture. **Uniqueness:** Cases of plastic fibular bowing have not been published within the last 25 years. Also, the epiphyseal plates of the patient were revealed by X-rays to be closed, ruling out greenstick and flexibility properties of the fibula. The bowing of the fibula also yielded no further injury to the ankle mortise, anterior compartment structures or syndesmosis. **Conclusion:** This case reminds athletic trainers that not every injury is straightforward. Further imaging and evaluation are needed in some cases to fully understand the extent of the injury. As with this case, what seemed to be a standard tibia fracture revealed acute traumatic plastic fibular bowing that is not consistent to what would be expected of a fully mature bone. This case also reveals the ability of the body to absorb and dissipate stresses placed on it.

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**Hyoid Bone Fractures In Division I Collegiate Football Players**

Rodriguez ER, Hendrickson CD, Johnson PD, Schmidt PW: University of Michigan, Ann Arbor, MI

**Background:** This case series report details two instances in which Division IA football players were diagnosed with hyoid bone fractures following blunt trauma to the throat during separate full-contact practices. Athlete I (21 yrs, 1.88 m, 90.72 kg) was a junior year defensive back who competed mainly on special teams. He described a direct blow mechanism to the right side of the anterior neck but was not able to remember the object with which he was struck. He was able to return to practice but presented afterwards with progressively worsening pain symptoms, difficult and painful swallowing, and difficulty breathing exacerbated while supine. Athlete II (21 yrs, 1.93 m, 95.25 kg) was a senior year wide-receiver who also competed mostly on special teams. He described being struck by his chin strap on the right side of his neck after colliding with another player. He too was able to continue activity and finish practice with no limitations and presented to the athletic training room following practice with complaints of painful swallowing and difficulty breathing exacerbated while supine. Both had similar presentations and described pain in the neck immediately following contact with no signs of airway compromise or respiratory distress, nor soft-tissue swelling or deformity. Tenderness at the anterior superior neck noted, but no crepitus upon palpation. Due to worsening symptoms in both cases, the athletes were referred to the emergency room for radiographs and further evaluation. Emergency room evaluations in both cases yielded similar results. Both athletes presented with normal vital signs, had no abnormalities of the naso-oral, laryngeal, and pharyngeal cavities as confirmed by scoping procedures, and had no significant soft tissue swelling or airway compromise. Furthermore both had an unremarkable cervical spine evaluation. Computed tomography imaging revealed a fracture of the right greater horn of the hyoid bone in both cases. Conservative management including overnight hospital observation was undertaken and athletes were subsequently released to the sports medicine staff for further care. There is no consensus on the management of hyoid bone fractures, an exceedingly rare

fracture, in the general population. Furthermore, return-to-play criteria in sport are scarce and become more difficult when dealing with a population that participates in a collision sport. **Treatment:** Initial treatment involved restraint from activity until symptoms subsided, followed by slow progression of low-impact cardiovascular exercise. Sport-specific non-contact drills followed when the athletes reported no symptoms with exertion. Activity progressed to non-contact practice and finally to regular, full-contact practice at 13 days and 7 days for Athlete I and II, respectively. **Results:** Athletes reported pain symptoms for only the first two days following injury. Neither reported pain nor discomfort with cardiovascular exercise or non-contact drills. Neither athlete reported any difficulty or symptoms after their first full-contact practice and were continually monitored at all full contact practices. At the 12 week post-injury follow-up, no complications from full-contact practices were reported. Both had participated regularly in intercollegiate football competitions. **Uniqueness:** These cases are unique due to the rarity of hyoid bone fractures, especially in competitive athletes. Most cases are a result of motor vehicle accidents or strangulation. The lack of consensus in the management of hyoid bone fractures combined with the limited evidence to guide return-to-play decisions poses unique challenges. **Conclusions:** Hyoid bone fractures in competitive athletes must be considered following trauma to the neck or throat. While most may be managed conservatively, the evaluation must be clinically vigilant to help prevent potentially catastrophic consequences

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**The Surgical And Rehabilitative Treatment Of A Scapholunate Interosseus Ligament Repair In A NCAA Division-1 Football Player: A Case Report**

Hart AC, Spake WA, Crowell D, Courson RW, Bolgla LA: University of Georgia, Athens, GA, and Medical College of Georgia, Augusta, GA

**Background:** This case report describes a scapholunate ligament repair and rehabilitation for an 18-year-old African-American collegiate running back. During an in-season practice, the athlete fell on an outstretched hand and sustained a left wrist hyperextension injury. Afterward, he reported pain with all wrist range of motion. The athlete presented acutely with significant swelling, decreased wrist extension, and increased tenderness over the scapholunate area. Based on these findings, the certified athletic trainer referred the athlete to a hand specialist for further diagnostic testing. **Differential Diagnosis:** scapholunate interosseous ligament tear, non-union scaphoid fracture, lunate fracture/dislocation, lunate instability, Bennett's fracture **Treatment:** On physical examination, the physician attempted to perform the Watson's test to determine the integrity of the scapholunate ligament. The athlete reported increased pain during the maneuver, precluding the physician's ability to assess ligament stability. Radiographs of the athlete's left wrist taken in the anterior-posterior view with the fist clinched showed an increased space between the scapholunate gap. Medial-lateral radiographs, taken with the wrist and hand in a neutral position, revealed an increased scapholunate interval of approximately 80 degrees. These findings indicated a torn scapholunate ligament, which was confirmed with MR imaging. Based on the athlete's functional demands and concerns regarding possible future degenerative changes, the athlete underwent surgical stabilization. The hand surgeon stabilized the scapholunate articulation via K-wire insertion and capsulodesis. Afterward, the athlete wore a hard cast for 10 weeks. Following this 10-week period, the surgeon removed the hardware and placed the athlete in a removable soft cast for an additional month. At this time, the athlete began gentle active-assisted wrist range of motion (ROM). He started a supervised rehabilitation program a month later that incorporated more progressive ROM and strengthening exercises. During this time, the athlete continued to lack functional left wrist ROM and the certified athletic trainer initiated movement with mobilization techniques as described by Mulligan. The athlete responded well to this intervention and continued with the rehabilitation program. The athlete began functional catching and blocking drills during the preseason practice sessions and returned to play for the regular season. **Uniqueness:** Injury to the scapholunate ligament typically occurs in sports requiring repetitive, weight bearing wrist extension like gymnastics. This injury often precludes an athlete to return to competition at a collegiate or professional level due to residual loss of ROM and function. This case is unique because a Division-I collegiate running back incurred this injury and successfully returned to play. Although surgeons generally use the surgical repair procedure performed on this athlete, limited evidence exists regarding post-operative care. In this case report, the athlete did not gain functional wrist ROM during conventional ROM exercise, leading to the use of the Mulligan techniques. The effective use of these techniques highlights the importance of restoring normal wrist arthokinematics to obtain the desired outcomes needed for return to play. **Conclusion:** Injury to the scapholunate ligament can end an athlete's collegiate or professional career. Results from this case report showed the successful return to play for a collegiate football player following a primary repair and capsulodesis following a scapholunate ligament injury.

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**Lower Extremity Muscle Activity And Kinematics During Dynamic Postural Control In Those With And Without Patellofemoral Pain Syndrome**


Aminaka N, Goto S, Gribble PA: The University of Toledo, Toledo, OH, and University of North Carolina, Chapel Hill, NC



**Context:** Although the influence of the vastus medialis oblique (VMO) and knee kinematics has been widely investigated in those with patellofemoral pain syndrome (PFPS), the contribution of the hip adductor (HA) group in combination with the VMO activity and knee movement on PFPS patients is relatively unexplored. **Objective:** To determine if individuals with PFPS demonstrate different knee kinematics and electromyographic (EMG) activity of the HA and VMO during a dynamic postural control task, compared to healthy individuals. **Design:** Case-control study. **Setting:** Research laboratory. **Patients or Other Participants:** Fourteen subjects with recently diagnosed PFPS (10F/4M; 21.07±3.59yrs; 172.09±10.26cm; 69.95± 9.05kg), and 14 healthy subjects (10F/4M; 20.93± 3.00yrs; 170.18±8.94cm; 70.25± 8.57kg) volunteered for the study. **Interventions:** Surface electromyography (EMG) for HA and VMO was collected using an 8-channel telemeterized EMG system. After performing maximum voluntary isometric contractions (MVIC) for HA and VMO against a strap, subjects were asked to perform 5 trials of the anterior direction of the Star Excursion Balance Test (SEBT). The SEBT was divided into the Down phase, which indicated the time from double-limb stance to the point of maximum reach (touchdown); and the Up phase, indicating the time from touchdown to a return to double-limb stance. Knee kinematics were recorded with an electromagnetic tracking system. Integrated EMG of the HA and VMO during the SEBT was normalized to the integrated EMG of the MVIC. **Main Outcome Measures:** Dependent variables were HA and VMO activity and overall sagittal and frontal plane knee displacement during the Down and Up phases of the SEBT. For each dependant variable, a separate one-way analysis of variance was applied. Standardized effect sizes (*d*) were calculated. **Results:** The individuals with PFPS demonstrated significantly higher normalized VMO activity (Down phase: PFPS= 168.74±93.33%MVIC, Healthy= 103.47± 37.66%, $F_{1,26}$=5.89, *P*=0.022, *d*=0.89; Up phase: PFPS=109.49±49.02%, Healthy= 65.35±23.91%, $F_{1,26}$=9.17, *P*= 0.005, *d*=1.11), and higher normalized HA activity (Down phase: PFPS=59.87±19.52%, Healthy= 44.12±17.25%, $F_{1,26}$=5.12, *P*= 0.032, *d*=0.83; Up phase: PFPS=38.81 ±16.31%, Healthy= 25.42± 15.50%, $F_{1,26}$=4.96, *P*=0.035, *d*=0.82) during both phases of the SEBT. Furthermore, significant group differences were found for frontal plane knee displacement during both phases (Down phase: $F_{1,26}$=7.06, *P*=0.013, *d*=0.98; Up: $F_{1,26}$=7.60, *P*=0.011, *d*=-1.01). PFPS subjects demonstrated a smaller range of frontal plane movement compared to healthy subjects in both the Down phase (PFPS= -2.06±6.88°; Healthy=-9.68±8.22°), and the Up phase (PFPS=0.02±9.03°; Healthy= 9.32 ±8.82°). There was no significant difference for the sagittal plane displacement. **Conclusions:** PFPS subjects demonstrated altered neuromuscular control of the VMO and HA and restricted frontal plane knee movement during both phases of the SEBT. Increased activity of the HA and VMO was associated with stiffer frontal plane knee movement in those with PFPS. Future research should include interventions for PFPS that address lower extremity muscle imbalances while ensuring wider availability of movement.


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**The Relationship Between Hip Abductor Muscle Strength And Knee Genu Valgum For PFPS Patients Following A Strengthening Protocol**


Ferber R, Kendall KD, Farr L: Faculty of Kinesiology, Running Injury Clinic, University of Calgary, Calgary, AB, Canada



**Context:** The hip abductor muscles have been theorized to eccentrically control hip adduction, and thus knee genu valgum, during running. However, few studies have investigated this relationship and no study has tested whether increased abductor strength would reduce genu valgum angle for patients with patellofemoral pain syndrome (PFPS). **Objective:** To determine the effect of a 3-week hip abductor strengthening protocol on changes in strength and running biomechanics for patients with PFPS. At baseline, we hypothesized that PFPS patients would exhibit reduced strength and a greater peak genu valgum angle compared to controls. Following the protocol, we hypothesized that muscle strength would increase and peak genu valgum angle would decrease compared to baseline. **Design:** Cohort intervention, repeated measures design. **Setting:** Clinical research laboratory. **Patients or Other Participants:** Fifteen PFPS patients (5 males, 10 females: age: 35.2±12.2 years; mass: 69.1±11.6kg) and 10 age and mileage-matched controls (4 males, 6 females: age: 29.9±8.3 years; mass: 73.1±15.7kg) participated. All participants ran a minimum of 20km per week. **Interventions:** Baseline measures of maximal isometric hip abductor muscle strength were recorded using a hand-held dynamometer. Two-dimensional (2D) knee kinematics were recorded using a 60Hz camera for 10 consecutive footfalls while running at 2.55 m/s. PFPS patients completed a 3-week hip abductor strengthening protocol consisting of two open-kinetic chain exercises and all measures of dependent variables were repeated. Control subjects were tested twice over the 3-week period of time but did not participate in the strengthening protocol. **Main Outcome Measures:** The average of 3 maximal isometric contractions were normalized to mass (%BW). 2D knee genu valgum angle (degrees) was derived from two thigh and two shank markers. Between- and within-group differences were determined using repeated measures ANOVAs and a priori post-hoc testing (*P*=0.05). **Results:** At baseline, PFPS exhibited 28.71% reduced strength (CON-Pre=18.11±3.89 %BW; PFPS-Pre=12.91±4.12 %BW: *P*=0.04) but no differences in peak genu valgum angle compared to controls (CON-Pre=2.67±1.19 deg; PFPS-Pre=3.71±1.38 deg: *P*=0.67). Following the 3-week protocol, a 32.69% increase in abductor strength (PFPS-Post=17.13±3.08 %BW: *P*=0.01) but no differences (PFPS-Post=3.05±1.34 deg: *P*=0.71) in peak genu valgum angle for PFPS were measured compared to baseline. At follow-up, no differences in either strength (CON-Post=18.49±2.99 %BW; *P*=0.67) or peak knee genu valgum angle (CON-Post=3.10±1.02 deg; *P*=0.22) were measured for controls compared to baseline. **Conclusions:** Significant increases in muscle strength were measured in the PFPS group after the strengthening protocol. No differences in peak genu valgum angle were measured between groups or concomitant with increases in hip abductor strength. These data suggest hip abductor muscle strengthening may not decrease peak knee genu valgum angle for PFPS subjects.


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**Effects Of A Lumbopelvic Joint Manipulation On Running Gait Mechanics Of Individuals With Patellofemoral Joint Pain**

Grindstaff TL, Franz JR, Beazell JR, Hertel J, Kerrigan DC, Ingersoll CD: University of Virginia, Charlottesville, VA; University of Colorado, Boulder, CO; Central Michigan University, Mt. Pleasant, MI

**Context:** Individuals with patellofemoral pain (PFP) demonstrate altered running mechanics compared to healthy individuals. A lumbopelvic joint manipulation has been shown to decrease subjective reports of PFP, but the effects on running mechanics are unknown. **Objective:** To examine changes in hip and knee joint kinematics and kinetics following a lumbopelvic joint manipulation in individuals with PFP. **Design:** A single-blind randomized control trial with one between-factor, group (lumbopelvic joint manipulation, lumbar passive range of motion (PROM), prone extension) and one within-factor, time (pre and post intervention) was used to compare peak hip internal rotation angles, peak knee external rotation at initial contact, peak knee varus, and peak external hip flexion moments during the stance phase of running. **Setting:** Motion analysis laboratory. **Participants:** Thirty-three individuals (mean±SD, Age=25.0±9.6 years, Mass=78.2±16.2 kg, Height=174.3±11.2 cm) with PFP at least one month in duration. **Interventions:** A 10 camera motion analysis system (VICON 624) and custom treadmill with 3 embedded force plates (Advanced Mechanical Technology, Inc., Watertown, MA) were used to capture kinetic and kinematic data while running at a self-selected pace for 3 minutes. During this time 3, 15-second trials were recorded for data analysis. Following randomized intervention (lumbopelvic joint manipulation, lumbar PROM, or prone on elbows) running kinetics and kinematics were reassessed. Separate single factor repeated measures ANOVAs were performed to compare changes in peak hip rotation angles, knee rotation at initial contact, peak knee varus, and peak external hip flexion moments. The probability was set at $P$ d•.05 for all statistical tests. **Main Outcome Measures:** Peak joint angles and moments (peak hip internal rotation angles, peak knee external rotation at initial contact, peak knee varus, and peak external hip flexion moments were calculated using raw ground reaction forces and kinematic data through a commercialized full-inverse dynamic model (VICON Plug-In-Gait). Kinetic data were normalized by body mass and height, and reported in Nm/kgm. **Results:** There were no significant differences ($P$ = .40) in peak hip internal rotation (degrees) between groups, Manipulation Pre=12.9±6.4, Post=14.1±6.3; PROM 25.3±18.3, Post= 24.9±22.4; Prone on Elbows Pre=20.8±11.4, Post=23.9±11.1. There were no significant differences ($P$ = .11) in peak knee external rotation (degrees) at initial contact between groups, Manipulation Pre=1.6±6.8, Post=1.9±7.6; PROM 8.7±12.7, Post= 7.9±12.6; Prone on Elbows Pre=10.7±9.8, Post=12.5±10.7. There were no significant differences ($P$ = .84) in peak knee varus (degrees) between groups, Manipulation Pre=7.6±5.6, Post=8.8±5.4; PROM 16.5±8.4 Post= 17.1±8.8; Prone on Elbows Pre= 11.9±6.6, Post=13.3±7.3. There were no significant differences ($P$ = .84) in peak external hip flexion moments (Nm/kg) between groups, Manipulation Pre=44.0±5.6, Post=44.5±6.0; PROM Pre=38.8±9.2, Post=39.0±9.1; Prone on Elbows Pre= 42.4±4.9, Post=42.2±5.0. **Conclusions:** Lumbopelvic joint manipulation does not seem to have an acute effect on running mechanics of individuals with PFP. Funded by the NATA Foundation Doctoral Research Grant Program and a Doctoral Grant from the University of Virginia Curry School of Education- Center for the Advanced Study of Teaching and Learning.

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**A Preliminary Analysis Of Gender Specific Risk Factors For Patellofemoral Pain Syndrome: The JUMP-ACL Study**

Boling MC, Padua DA, Marshall S, Beutler AI: University of North Florida, Jacksonville, FL; University of North Carolina, Chapel Hill, NC; Uniformed Services University of the Health Sciences, Bethesda, MD

**Context:** Females are reported to be twice as likely to develop patellofemoral pain syndrome (PFPS) compared to males. Prospective risk factor investigations have yet to determine if biomechanical risk factors for PFPS differ between males and females. Gaining an understanding of gender specific risk factors may help to explain the predisposition of females to PFPS. **Objective:** To determine the association between biomechanical variables and risk of incident PFPS in males and females. **Design:** Prospective cohort. **Setting:** US Military Academy. **Patients or Other Participants:** The cohort consisted of 1,319 cadets (females=513, males=806) who were freshmen at the time of enrollment in the current investigation. This cohort is part of a larger scale investigation of risk factors for ACL injury (JUMP-ACL). **Interventions:** Each participant underwent a baseline biomechanical assessment including three-dimensional motion analysis during a jump-landing task, assessment of peak isometric strength of thigh and hip musculature, and measurement of Q-angle and navicular drop. Following baseline data collection, participants were followed prospectively for a maximum of 4 years to determine those diagnosed with PFPS. Incident PFPS was determined by a manual review of medical records by the principal investigator in which the following criteria needed to be met for inclusion in the injured group: 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, bursae, and synovial plica. **Main Outcome Measures:** Peak sagittal, frontal, and transverse plane hip and knee kinematics during the jump-landing task, peak isometric strength of the knee flexors, knee extensors, hip extensors, hip abductors, hip internal rotators, and hip external rotators, Q-angle, and navicular drop were included in the data analysis. Separate Poisson regression analyses were performed to determine the risk of PFPS in males and females for each biomechanical variable ($\alpha \leq 0.05$). **Results:** Sixty-three midshipmen were diagnosed with PFPS during the follow-up period (females=34, males=29). None of the biomechanical variables were found to be gender specific risk factors for incident PFPS ($P$>0.05). Although not significant, risk factors tended to differ between males and females for transverse plane motion at the hip (Males: Rate Ratio (RR)=1.82, 95% Confidence Interval (CI)=0.78, 4.28, $P$=0.17; Females: RR=0.88, 95% CI=0.36, 2.14, $P$=0.77) and knee (Males: RR=0.76, 95% CI=0.31, 1.88, $P$=0.56; Females: RR=1.78, 95% CI=0.77, 4.10 , $P$=0.17). **Conclusions:** This preliminary analysis reveals that biomechanical risk factors for PFPS may not differ between males and females; however, based on the observable differences in rate ratios, increased hip internal rotation in males and increased knee internal rotation in females seem to influence the risk of incident PFPS. Future research should investigate additional variables (i.e. psychosocial factors) to determine risk factors influencing the increased predisposition of females to PFPS (*Funded by the NIAMS Division of the National Institutes of Health, #R01-AR050461001, National Academy of Sports Medicine, and the National Basketball Athletic Trainers' Association)*

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# Free Communications, Oral Presentations: Examining Postural Control in those with Ankle Instability

Friday, June 25, 2010, 11:15AM-12:15PM, Room 203AB, Moderator: Jennifer McKeon, PhD, ATC

### Dorsiflexion Range Of Motion Significantly Influences Dynamic Balance

McKeon PO, Hoch MC, Staton GS: University of Kentucky, Lexington, KY

**Context:** Limited evidence exists to suggest that dorsiflexion range of motion significantly influences performance on the Star Excursion Balance Test (SEBT). **Objective:** To examine the relationships between dorsiflexion range of motion on the weight-bearing lunge test (WBLT) and the normalized SEBT reach distance in 3 directions. **Design:** Correlational study. **Setting:** Laboratory. **Patients or Other Participants:** Thirty-five healthy adults (14 males, 21 females, age: 25.9±6.7 years, height: 166.7±22.89cm, weight: 76.7± 22.8kg) participated. All subjects had no history of lower extremity injury in the past six months and no history of lower extremity surgery or balance disorders. **Intervention(s):** All subjects performed 3 trials of maximum reach in the anterior (ANT), posteromedial (PM) and posterolateral (PL) directions of the SEBT on each limb to assess dynamic balance. Prior to testing, each participant performed 4 practice trials in each direction for each limb. Reach distance for each trial was normalized to leg length. The WBLT was used to measure dorsiflexion range of motion. 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. **Main Outcome Measures:** Dependent variables included the mean of the SEBT normalized reach distances in the ANT, PM, and PL directions and the mean of the WBLT for each limb. Because there were no significant differences between limbs on any of the tests, the right and left means for each dependent variable were pooled. Bivariate Pearson product moment correlation coefficients were calculated among the 4 dependent variables for the pooled means from both limbs to examine the relationships between the WBLT and the SEBT directions. Alpha level was set a priori at $p<0.05$. **Results:** Only the ANT direction (mean:79.0±5.8%) of the SEBT was significantly correlated to the WBLT (mean:11.9±2.7cm), $r=0.53$ ($p=0.001$). The $r^2$ for this correlation was 0.28, indicating that the WBLT explained 28% of the variance in the ANT normalized reach distance. There were no significant correlations between the WBLT and the PM direction (mean:90.0±9.1%, $r=0.21$, $p=0.23$) or the PL direction (mean: 82.0± 13.1%, $r=0.22$, $p=0.20$). All 3 SEBT normalized reach distances were significantly correlated, ANT to PM direction ($r=0.60$, $p<0.001$), ANT to PL ($r=0.61$, $p<0.001$), PM to PL ($r=0.89$, $p<0.001$). **Conclusions:** The WBLT explained a significant proportion of the variance within the ANT reach distance. The ANT direction of the SEBT may be a good clinical test to assess the effects of dorsiflexion range of motion restrictions on dynamic balance.

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### Wearing Five-Toed Socks Improves Static Postural Control In Individuals With And Without Chronic Ankle Instability

Shinohara J, Gribble PA: University of Toledo, Toledo, OH

**Context:** In Japan, five-toed socks with grippers on the sole of the foot are being worn by athletes and are gaining popularity because of the perceived improvements in balance that result from their wear. However, no scientific research has been conducted to examine the effectiveness of the socks. **Objective:** To compare the effectiveness of the five-toed socks with grippers on the sole of the foot in influencing static postural control among subjects with chronic ankle instability (CAI). **Design:** Case-control, crossover. **Setting:** Research Laboratory Setting. **Patients or Other Participants:** Twenty subjects (7 males, 13 females: 20.35±2.37 yrs, 169.67±9.01 cm, 69.28±14.72 kg) with self-reported CAI and 20 matched healthy controls (7 males, 13 females: 22.90±3.29 yrs, 168.81±9.76 cm, 68.73±13.32 kg) volunteered to participate. **Interventions:** Subjects were asked to complete three testing sessions, separated by approximately one week, to measure static postural control under three sock conditions: wearing five-toed socks with grippers on the sole (FS), wearing regular socks (RS), and wearing no socks (NS). For each sock condition, static postural control was assessed on a force plate (model 4060NC; Bertec Corp Inc., Columbus, OH) with the subject in a single-limb stance with eyes open (EO) and eyes closed (EC). The subjects were instructed to stand on the dominant limb (leg used to stand on while kicking a ball) as still as possible for 15 seconds. Center of pressure (COP) data were sampled at 50Hz. The subjects completed three 15-second trials with a one-minute rest between trials for EO and for EC. Sock conditions were randomized. Center of pressure data collected during the single-limb balance testing was utilized to calculate Center of Pressure Velocity (COPV). **Main Outcome Measures:** The dependent variables were the COPV in the anteroposterior (COPVAP) and mediolateral (COPVML) directions with EO and EC trials. The independent variable was Sock (FS, RS, and NS) and Group (CAI, Control). For each dependent variable, a Sock by Group repeated measures ANOVA was performed. Significance was set a priori at $P<0.05$. **Results:** A significant main effect for Sock was observed for COPVML during the EO condition ($F_{2, 37}=5.500$, $P=0.006$). Tukey's post-hoc test revealed that the FS (0.568±0.219 cm/sec) showed a significantly lower COPVML value than the RS (0.618±0.295 cm/sec) and NS (0.631±0.298 cm/sec). There was no significant influence of Group in any of the three sock conditions. **Conclusions:** These results indicate that the FS condition is associated with increased static postural stability when compared to the RS and NS conditions. Continued research is needed to determine if this style of sock is able to influence balance differently in subjects with lower extremity pathology.

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### The Postural Stability Of Individuals With Functional Ankle Instability Following Orthotic Intervention

Hamlyn CJ, Docherty CL, Klossner J: Indiana University, Bloomington, IN

**Context:** Most treatment protocols established to manage athletes with functional ankle instability (FAI) have focused on the taping of the ankle. Orthotics have recently been investigated as a possible treatment of FAI. To date limited studies have investigated how orthotic use may affect postural stability (PS) in people with FAI. **Objective:** To determine if the use of orthotics will affect the PS of subjects with FAI. **Design:** Repeated measures. **Setting:** Athletic Training research laboratory. **Patients or Other Participants:** Forty subjects (age=20.2±2.2 yrs; height=175.4±10.3 cm; mass=74.6±17.5 kg) participated in this study. All subjects had unilateral FAI and no history of injury to the contralateral ankle. Subjects were randomly assigned to either the orthotic or control groups. **Interventions:** PS was measured on both limbs using a force plate (Advanced Medical Technology Inc, Watertown, MA) on three separate occasions. Subjects were instructed to balance on one limb with their eyes closed for 20 seconds. If the subject lost their balance they were asked to return to the test position as quickly as possible. Three balance trials were conducted on each day. On day 1 PS was measured with the subject wearing their

own low-top athletic shoes. The control group repeated this same procedure on days 2 and 3. The orthotic group returned on day 2 and received an "off the shelf" full length Quick Comfort Insole (Foot Management Inc.) for both feet. Subjects immediately placed the orthotic in their shoes and PS was tested. Subjects were then instructed to wear the orthotics for one hour on the first day and increase use of the orthotic by approximately one hour every subsequent day. The orthotic group returned two weeks later for day 3 of testing and repeated the PS testing. **Main Outcome Measures:** For each trial 95% ellipse ($cm^2$) was calculated as the value which encircled 95% of the center of pressure data. The average of the three trials was used for statistical analysis. A repeated measures ANOVA was calculated with two within subjects factors: Side (FAI, Healthy) and Day (1, 2, 3) and one between subjects factor: Group (Orthotic, Control). Alpha level was set at $p<.05$. **Results:** We identified a significant day by group interaction ($F_{2,76}=4.18$, $p=.02$). Specifically, in the orthotic group there was a significant improvement in PS between days 1($52.2\pm5.5$ $cm^2$) and 3 ($37.6\pm3.6$ $cm^2$). We also identified a significant difference between the sides ($F_{1,38}=6.98$, $p=.01$) where the FAI ankle ($49.3\pm3.4$ $cm^2$) had significantly worse PS than the healthy ankle ($42.6\pm3.0$ $cm^2$). **Conclusions:** An over the counter orthotic seems to improve postural stability after a two week adjustment period. Additionally, similar to previous research postural stability is worse in functionally unstable ankles compared to healthy ankles.

**The Effect Of Ankle Support On Postural Stability Using The BESS Test**

Herter N, Covassin T, Mackowiak T, Kovan J: Department of Kinesiology, Michigan State University, East Lansing, MI, and Department of Intercollegiate Athletics, Wayne State University, Detroit, MI

**Context:** The Balance Error Scoring System (BESS) is commonly used to evaluate impairment of balance and coordination following a concussion. An athletes' post-concussion test primarily takes place on the sidelines with several extraneous variables that may affect balance. Specifically, the BESS test is performed in competitive shoes, ankle and knee bracing, or ankle prophylactic tape, all of which may affect an athletes' BESS test scores. **Objective:** To investigate the effect of wearing an ankle brace or ankle tape on postural control. **Design:** Quasi-experimental counterbalance design. **Setting:** Research laboratory. **Participants:** A total of 26 male (age = 21.64 ± 2.58 years, 70.60 ± 3.24 inches, 176.72 ± 27.49 lbs.) and 29 female (age=21.41 ± 2.85 years, 65.14 ± 2.68 inches, 143.66 ± 21.05 lbs.) recreationally active collegiate students volunteered to participate in this study. Participants with chronic ankle instability, a lower leg injury within the past six months, a head injury within the past 12 months, otitis media, or Meniere disease were excluded from this study. **Intervention:** The BESS test consists of six-20 second trials performed on two surfaces (foam and firm) across three stances (double leg, single-leg, tandem). An error was recorded for every time the participant opened their eyes, stepped, stumbled, or fell out of test position, removed their hand(s) from their hip(s), moved their hip into more than 30 degrees of flexion or abduction, lifted their toes or heels from testing surface, or remained out of the test position for longer than five seconds. The independent variable was ankle condition (ankle tape, ankle brace, no ankle support). For the ankle tape condition, participants had both ankles taped using a closed basket weave, while the ankle brace condition consisted of wearing a DonJoy Stabilizing Ankle brace on both ankles. All participants randomly performed all six stances with ankle tape, ankle brace and no ankle support with a five-minute rest between each condition. A repeated measure MANOVA was used to determine group differences with alpha level of $p<.05$ set a prior. **Main Outcome Measurements:** The dependent variables were BESS total scores for ankle tape, ankle brace, and no ankle support. **Results:** There were significant differences between ankle conditions ($p< .001$). Specifically, pairwise comparisons indicated that the ankle tape condition ($15.49\pm5.31$) was significantly worse than the ankle brace ($13.91\pm4.91$, $p=.046$) and no ankle support ($12.04\pm5.03$, $p<.001$) conditions. Participants wearing an ankle brace performed significantly worse compared to the no ankle support ($p=.005$) condition. **Conclusions:** This study demonstrated that ankle tape or ankle brace has an effect on an individual's postural stability as measured by the BESS test. The BESS test should be performed in the same conditions for baseline measures in which post-injury testing will most likely be conducted.

## Free Communications, Oral Presentations: Examining Postural Control in those with Ankle Instability Cont.

Friday, June 25, 2010, 12:30PM-1:30PM, Room 203AB, Moderator: Jennifer McKeon, PhD, ATC

**Differential Ability Of Selected Postural Control Measures In The Prediction Of Chronic Ankle Instability Status**

Knapp DT, Lee SY, Chinn L, Saliba S, Hertel J: University of Virginia, Charlottesville, VA, and University of Miami, Coral Gables, FL

**Context**: Balance deficits, as evaluated with force plate measurements, have been associated with chronic ankle instability (CAI). However, the best measure to discriminate between individuals with and without CAI is unknown. **Objective**: To determine the differential ability of selected force plate postural control measures to predict CAI status. **Design**: Case control. **Setting**: Laboratory. **Patients or Other Participants**: Sixty-three individuals with self-reported CAI (30 males, 33 females, age=22.3±3.7 years, height= 169.8±9.6 cm, mass=70.7±14.3 kg) and 46 healthy controls (22 males, 24 females, age=21.2±4.1 years, height=173.3±9.2 cm, mass=69.2±13.2 kg) participated. **Intervention(s)**: The independent variable was group (control, CAI). Subjects performed three 10-second trials of quiet single limb stance on a force plate in two conditions; eyes open and eyes closed. Data were sampled at 50Hz. **Main Outcome Measures**: Measures of center of pressure (COP) area, COP velocity, COP standard deviation (SD), COP range of excursion, percent COP range used, time to boundary (TTB) absolute minimum, TTB mean of the minima, and TTB SD of the minima were calculated. All measures with the exception of COP area were calculated in both the mediolateral (ML) and anteroposterior (AP) directions. The mean of three trials for each measure was used for statistical analysis. For each outcome measure, a receiver operator curve (ROC) analysis was performed to determine the ability of the measure to predict CAI status and the corresponding area under the curve (AUC) was tested for statistical significance. The optimal diagnostic threshold value for each measure was determined from the ROC and the associated positive and negative likelihood ratios (LR) were calculated. **Results**: Three measures significantly

predicted CAI status: eyes closed COP ML SD (CAI=.45±.08 cm, Control=.42±.06 cm, threshold=.47 cm, positive LR=2.37, negative LR=.71, AUC=.61, p=.04), eyes closed ML percent range used (CAI= 18.7±2.7.9%, Control= 17.4±1.9%, threshold=18.8%, positive LR= 2.19, negative LR=.67, AUC=.65, p=.01), and eyes closed TTB ML absolute minimum (CAI=.52±.09s, Control=.49±.11s, threshold =.46s, positive LR = 2.67, negative LR=.59, AUC=.63, p=.03). The large number of dependent measures precludes the reporting of means and SD of the non-significant measures. **Conclusions***:* Three force plate measures of eyes closed single limb stance (COP ML SD, ML percent range used, and TTB ML absolute minimum) significantly predicted CAI status, however all three had positive LR associated with only small shifts in the probability of a patient with a positive test (a score above the threshold) having CAI, and negative LR associated with very small shifts in the probability of a patient with a negative test (a score below the threshold) not having CAI. No single force plate measure was very effective at predicting if an individual had CAI or not. Force plate postural control measures may be better used as outcome measures rather than as diagnostic tools.

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**Effects Of Rehabilitation Incorporating Short Foot Exercises On Self-Reported Function, Static And Dynamic Balance In Chronic Ankle Instability Patients**

Sauer LD, Saliba SA, Ingersoll CD, Kerrigan DC, Pietrosimone BP, Hertel J: University of Virginia, Charlottesville, VA; Central Michigan University, Mount Pleasant, MI; University of Toledo, Toledo, OH

**Context:** Chronic ankle instability (CAI) patients have previously improved self-reported function and static and dynamic balance following rehabilitation. Incorporating exercises focusing on intrinsic foot muscles, like the short foot exercise (SFE), into rehabilitation may result in greater improvement of balance and function while developing a more stable base of support. **Objective:** To compare self-reported function, static and dynamic balance between CAI subjects in traditional and SFE rehabilitation groups before and after rehabilitation. **Design:** Double-blind randomized controlled trial. **Setting:** Laboratory. **Patients or Other Participants:** Thirty participants with CAI volunteered and were screened for eligibility according to injury history and self-reported function on the Foot and Ankle Ability Measure (FAAM). Subjects were randomly assigned to a traditional ankle rehabilitation program (CON) or experimental group with rehabilitation incorporating the SFE (EXP), (EXP: n=17, 22.7±3.4 yrs, 174.8±11.5 cm, 78.0±16.0 kg; CON: n=13, 22.0±5.1 yrs, 171.7±10.9 cm, 69.1±14.6 kg). **Interventions:** Rehabilitation involved twelve supervised sessions of stretching, strengthening, balance and coordination training over 4-weeks. The EXP rehabilitation program was identical to the CON program, but incorporated the SFE into single-limb exercises. Baseline and 4-week measurements of self-reported function, static and dynamic balance were assessed. **Main Outcome Measures:** Self-reported function was a percentage on the FAAM-activities of daily living (FAAM-ADL) and FAAM-sport subscales. Static balance was assessed during static, single-limb balance with eyes open and closed with measures of time-to-boundary (TTB) absolute minimum in the medial-lateral (ML) and anterior-posterior (AP) directions. Dynamic balance measures were reach distance normalized to leg length in anterior, posteromedial and posterolateral directions on the Star Excursion Balance Test (SEBT). **Results:** There was a significant time×group interaction ($P$=0.024) for FAAM-Sport values where the EXP group demonstrated higher self-reported function following 4-weeks of rehabilitation (baseline= 58.2±16.0%, follow-up=88.5%±8.0%) compared to the CON group (62.5±12.6%, 79.8±12.1%). There was a significant main effect for time on both the FAAM-ADL (EXP: 85.2±8.9%, 96.1±2.9%; CON:88.1±8.8%, 94.8x±3.9%; $P$<0.001) and FAAM-Sport (EXP:58.2± 16.0%, 88.5x± 8.0%; CON:62.5x±12.6%, 79.8± 12.1%; $P$<0.001). There was not a significant time×group interaction on the FAAM-ADL (EXP= 85.2±8.9%, 96.1x±2.9%; CON=88.1 ±8.8%, 94.8±3.9%, $P$=0.156). With the eyes open, there was a significant main effect for time on TTBML-absolute minimum (EXP:1.11±0.23s, 1.24±0.33s CON:1.20 ±0.41s, 1.40±0.23s; $P$=0.01) and TTBAP-absolute minimum (EXP:3.73±1.09s, 4.26±1.02s; CON:3.73± 1.48s, 4.59±1.17s; $P$=0.006). With the eyes closed, there was a main effect for time on TTBML-absolute minimum (EXP:0.51±0.10s, 0.58±0.15s; CON:0.51±0.16s, 0.60±0.10s; $P$=0.014) and TTBAP-absolute minimum (EXP:1.45± 0.52s, 1.60±0.57s; CON:1.36 ±0.27s, 1.76±0.57s; $P$=0.006). There was a main effect for time during dynamic balance in anterior (EXP:60.2±6.5%, 63.3±5.2%; CON:60.0 ±9.9%, 63.3±9.4%;$P$=0.001), posteromedial (EXP:80.2±11.7%, 86.1±10.2%; CON:76.7x± 11.5%, 84.4x±7.8%;$P$<0.001) and postero-lateral directions (EXP:74. 9±13.3%, 83.1±10.6%; CON:76.1±8.7%, 82.3±7.0% ;$P$<0.001). **Conclusions:** An improvement in CAI patient-reported function with the incorporation of the SFE into rehabilitation is an important finding for patients and clinicians. Given this result, we recommend incorporation of the SFE into rehabilitation program for patients with CAI. This study was funded by a National Athletic Trainers' Association Research and Education Foundation Doctoral Grant.

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**Effect Of Wii Fit® And Traditional Rehabilitation On Static Postural Control In Individuals With Non-Acute Lower Extremity Injuries**

Sims J, Cosby NL, Hertel J, Saliba EN, Saliba S: University of Virginia, Charlottesville, VA

**Context:** Postural control deficits persist following lower extremity injuries and therapeutic exercise may improve these deficits. Video games have been suggested as rehabilitation tools, however their effectiveness has not been examined. **Objective:** To determine the effects of Wii Fit® rehabilitation on postural control in patients with non-acute lower extremity joint injuries. **Design:** Single blinded, randomized controlled trial. **Setting:** Athletic training clinic. **Participants:** Twenty-eight physically active subjects (age= 21.61±2.41 years, weight=73.29±10.43 kg, height=173.08±9.04 cm) with non-acute lower extremity joint injuries participated. **Interventions:** Subjects were randomly assigned to 1 of 3 treatment groups: Wii Fit® (n=9), traditional (n=10), and control (n=9). Subjects in the traditional and Wii Fit® groups participated in supervised rehabilitation 3 days a week over 4 weeks. Subjects in the control group were instructed to continue normal activities of daily living. **Main Outcome Measures:** Static balance was assessed using time to boundary (TTB) measures of the mean of minima in the mediolateral (ML) and anteroposterior (AP) directions with eyes opened and eyes closed. Measurements were recorded at baseline, 2 weeks, and 4 weeks. For each measure a 3x3 group by time ANOVA was calculated and Tukeys post hoc tests were performed to identify specific differences. Significance was set *a priori* at P<.05) **Results:** In the eyes open condition, a significant group by time interaction was observed for the TTBAP mean of the minima (p=.02). The Wii Fit® group improved significantly (P<.05) over both follow-ups (pre=11.70±3.44s, 2-weeks=14.24±1.92s, 4-weeks=16.72±3.44s), while no significant differences were found across time for the control group (pre=13.69±4.25s, 2-weeks=12.99±2.34s, 4-weeks=12.44±2.70s). Interestingly, compared to baseline (10.77±3.59s), the traditional group had a significant improvement (p<.05) at 2-weeks (12.89±6.44s) but not 4 weeks (11.16± 5.31s). There was no significant group by time

interaction or group main effect for the eyes open TTBML mean of the minima (p=.59, p=.19, respectively), however a significant time main effect (p=.01) was observed indicating improvement across all groups (control: pre=4.34±1.97s, 2-weeks=4.11±1.42s, 4-weeks=4.64±2.02s; traditional: pre= 3.57±1.61s, 2-weeks=3.78±1.46s, 4-weeks= 3.98±2.11s; Wii Fit® : pre=3.77±0.74s, 2-weeks=3.72±0.98s, 4-weeks=5.42±1.16s). With eyes closed there was no significant group by time interaction or time or group main effects for the TTBML (p=.57, p=.32, p=.82, respectively) or TTBAP mean of the minima (p=.16, p=.26, p=.73). Descriptive measures were as follows for the for the eyes closed TTBML mean of the minima (control: pre=1.64±0.64s, 2-weeks=1.92±0.55s, 4-weeks=1.86±0.75s, traditional: pre=1.62± 0.55s, 2-weeks=1.74±0.55s, 4-weeks=1.72 ±0.59s, Wii Fit®: pre=1.75±0.29s, 2-weeks=1.62±0.42s, 4-weeks=1.96±0.41s) and eyes closed TTBAP mean of the minima (control: pre=5.34±1.27s, 2-weeks= 5.00± 1.05s, 4-weeks=5.16±1.25s; traditional: pre=4.49± 1.91s, 2-weeks=5.20±2.41s, 4-weeks= 4.54±1.71s; Wii Fit® : pre= 4.42± 1.42s, 2-weeks=5.17±0.70s, 4-weeks= 5.91±1.93s). **Conclusions:** In subjects with non-acute lower extremity joint injuries, rehabilitation using the Wii Fit® produced positive benefits for eyes open static postural control compared to traditional rehabilitation and control interventions.

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**CAI Subjects Show Spinal Rotation Differences At Maximal Reach Of The Star Excursion Balance Test**

de la Motte SJ, Arnold BL, Ross SE: Injury Prevention Research Laboratory, Uniformed Services University of the Health Sciences, Bethesda, MD, and Sports Medicine Research Laboratory, Virginia Commonwealth University, Richmond, VA

**Context:** CAI subjects demonstrate decreased functional reach on the Star Excursion Balance Test (SEBT). While lower extremity sagittal differences appear to be associated with these deficits in CAI subjects, comprehensive trunk and lower-extremity kinematics have not been investigated. **Objective:** To determine if reach distance and kinematics for the trunk and lower extremity differed in chronic ankle instability (CAI) subjects. **Design:** Case-control. **Setting:** Sports Medicine Research Laboratory. **Patients or Other Participants:** Twenty subjects with CAI (24.2±3.8yrs; 169±11.6cm; 69±12.4kg) and twenty healthy subjects (25.7±5.6yrs; 170.1±8.8cm; 69.9±10.5kg) with no history of ankle sprain. All subjects were recreationally active. CAI was defined as repeated episodes of ankle "giving way" and/ or "rolling over". All CAI subjects scored ≤ 26 on the Cumberland Ankle Instability Tool. **Interventions:** SEBT reaches in the AM, M, and PM directions. CAI subjects used their unstable side as the stance leg, while control subjects were gender, height, mass and side-matched to the CAI group. Three-dimensional kinematic data were collected during SEBT performance. The effects of group on reach distance (normalized to leg length) and three-dimensional trunk and lower extremity kinematics were assessed with independent t-tests. **Main Outcome Measures:** Normalized reach distance, spine, pelvis, hip, knee, and ankle joint angles at the point of maximum SEBT reach. **Results:** No reach distance differences were detected between CAI and uninjured (UI) subjects in any reach direction (AM: UI 73.16±6.49; CAI 74.37±6.32; $t_{38}$= .442, P=.66; M: UI 75.20±8.92; CAI 77.94±8.35; $t_{38}$=.942, P=.35; PM: UI 77.48±11.74; CAI 80.13±10.34; $t_{38}$=.762, P=.45). With AM reach, stance leg hip flexion (UI 23.36±14.65; CAI 36.31±19.23, $t_{38}$=2.40, P=.002), spinal rotation toward the stance leg (UI -3.76±10.25; CAI -30.35±37.43, $t_{38}$=3.06, P=.004), and pelvic rotation toward the stance leg (UI 2.84±9.66; CAI -23.96±36.58, $t_{38}$=3.17, P=.003) were significantly greater in CAI subjects. For M reach lumbar spinal flexion towards the stance leg was significantly higher for CAI subjects (UI 14.82±9.15; CAI 21.61±11.92, $t_{38}$=6.39, P=.05). No kinematic differences were seen with PM reach (P>.05). **Conclusions:** We were unable to detect functional performance deficits with SEBT reach but did identify proximal joint angle differences at maximum reach, representing unique movement patterns in CAI. CAI subjects used a more proximal strategy to maintain their center of mass over the base of support when reaching, using increased spinal and pelvic motion towards the stance leg. This has not previously been reported and suggests less reliance on distal joint motion to achieve the task. Whether these differences are inherent in those who eventually develop CAI or the result of impaired neuromuscular feedback from repetitive injury at the ankle is unknown.

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**Reliability And Accuracy Of A Digital Photograph Method For Measuring Arch Height Index And Foot Structure**


Bachand A, Farr L, McElroy LK, Rabbito M, Pohl MB, Ferber R: Faculty of Kinesiology, Running Injury Clinic, University of Calgary, Calgary, AB, Canada


**Context**: Static anatomical foot structure has been associated with dynamic foot motion and has also been shown to play a role in the aetiology of musculoskeletal injuries. Arch index devices are used to measure different foot structural parameters and have been validated using radiographic measurements. Unfortunately, arch index devices are not readily available and are expensive to custom-manufacture. New safe, easy, and cost-effective methods for measuring static foot structure can be obtained using digital photography. However, no study has determined the reliability of foot measures using digital photography compared to an arch index device. **Objective:** The purpose of this study was to determine the reliability and measurement accuracy of a digital photographic method compared to an arch index device. **Design:** Cross-sectional reliability analysis. **Setting:** University clinical research laboratory. **Patients or Other Participants:** Sample of 10 volunteers (2 male, 8 females; age 22.3±8.4 years; mass 72.2±14.1kg). **Interventions:** A custom-manufactured arch index device was used to measure the following variables: total foot length (TFL), truncated foot length (TrFL), height of the dorsum (DH) of the foot at 50% TFL. Measures were taken while the subjects were seated and with 10% body weight accepted onto the right foot. A standard scale was used to ensure body weight distribution. Arch height index (AHI) was calculated from these measures (AHI=DH/TrFL). The arch index device was removed and a Canon Powershot A30 digital camera was then placed perpendicular and 50 cm away from the longitudinal axis of the foot, 6.2 cm above the floor to approximate the level of the medial malleolus and a digital photograph was taken of the medial aspect of the foot under the same loading condition. IMAGEJ software (NIH, Bethesda MD) was used to obtain the same foot measurement variables from the digital pictures. **Main Outcome Measures:** ICC (2,k) and descriptive analysis of TFL, TrFL, DH, and AHI at 10% BW were obtained for the arch index device and digital photographic method. **Results:** Differences ranging from 0.4% to 3.5% in magnitude were measured between the two measurement methods for TFL (TFL-device= 25.1±1.5cm; TFL-photo= 25.8±2.1cm), TrFL (TrFL-device=18.1±1.0cm; TrFL-photo= 18.9±1.8cm), DH (DH-device= 7.4±0.4cm; DH-photo= 7.5±0.7cm), and AHI (AHI-device= 0.4±0.1; AHI-photo= 0.5±0.1). Absolute differences for TFL, TrFL, DH, and AHI measures between the two measurement methods were 0.7±0.8cm, 0.8±0.8cm, 0.1±0.2cm, and 0.1±0.1, respectively. TFL had the highest correlation between the two measurement methods (r=0.94) followed by AHI (r=0.92), TrFL (r=0.91), and DH (r=0.82). **Conclusion:** Digital photography is a reliable and a comparably accurate method for obtaining static foot measurements.

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**Gender Differences In Postural Control Among Collegiate Basketball Athletes**


Noel BL, McLoda TA: Illinois State University, Normal, IL


**Context**: Inversion ankle sprains are the most common injury among physically active individuals. Postural control has been determined as a contributing factor related to the awareness of joint position and the ability to overcome unexpected inversion that would otherwise lead to trauma. **Objective**: To determine if gender differences in postural control are apparent among NCAA Division I basketball athletes. **Design**: Descriptive study. **Setting**: Controlled university laboratory. **Patients or Other Participants**: Convenience sample of 11 female (19.9±1.38 y; 177.8±9.5 cm; 79.3±13.41 kg) and 14 male (20.0±1.49 y; 194.1±9.7 cm; 95.7±11.54 kg) healthy NCAA Division I basketball players. Subjects were excluded if they experienced any grade of dominant leg ankle sprain during the past 8 months. **Interventions**: A force plate (AMTI Accusway, Watertown, MA) was used to record 3 randomized trials for each leg. Trials were single-legged, eyes-closed, and 10 sec in length. Hands were on the ASISs and the non-test leg was held in hip flexion off the force plate, anterior to the test leg. Data were collected at 100 Hz and were processed using a fourth order Butterworth filter. Two sample, equal variance t-tests were used to determine statistical significance between the means for displacement and for velocity of the dominant leg between men and women. Alpha level was .01. **Main Outcome Measures**: Mean values of displacement and velocity (anterior/posterior, medial/lateral, radial) of the 3 trials for the dominant leg. **Results**: The mean values for medial/lateral displacement of the dominant leg between the men (-5.18±1.72 cm) and women (-7.35±1.70 cm) were found to be significantly different (p=0.004). The mean values for anterior/posterior displacement of the dominant leg between the men (9.04±2.49 cm) and women (5.25±2.44 cm) were also found to be significantly different (p=.001). However, the mean values for radial displacement did not differ between the men (1.54±0.27 $cm^2$) and the women (1.63±0.52 $cm^2$; p=.552). No significant differences were found for medial/lateral velocity between men (33.30±9.63 cm/sec) and women (39.52± 18.10 cm/sec; p=.280). There were also no significant differences found for anterior/posterior velocity between men (37.46±12.29 cm/sec) and women (34.57±17.59 cm/sec; p=.633). **Conclusions**: We concluded that among the men and women basketball players with no history of ankle sprain in the last 8 months, the men demonstrated better overall postural control in 2 planes but showed no difference in the means of the radial displacement or in velocity. Based upon prior research that links postural control to proprioception, the women may be at a higher risk for ankle sprains than the men.

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**Effect Of Augmented Feedback On Co-Activation Ratio And Knee Valgus In Individuals With Medial Knee Displacement**


Oates DC, Bell DR, Goerger BM, Zinder SM, Padua DA: Sports Medicine Research Laboratory, University of North Carolina at Chapel Hill, Chapel Hill, NC


**Context:** Knee valgus angle and moment are potential risk factors for ACL injury. Techniques to decrease these variables are believed to be important for ACL injury prevention programs. Augmented feedback (AF) is used to alter ground reaction forces. The use of AF may also change muscle co-activation, especially between hip abductors and adductors, and knee valgus angle or moment. **Objective:** To determine if AF changes hip muscle co-activation and knee valgus biomechanics. **Design:** Randomized control trial. **Setting:** Research Laboratory. **Patients or Other Participants:** Participants were selected based on double leg squat (DLS) performance. Participants had to have visual medial knee displacement (MKD) during the squats that was corrected when squats were performed on a 2-inch heel lift for inclusion.

MKD was defined as the midpoint of the patella moving medial to the great toe. Participants meeting these criteria were randomly assigned to a control (n=16, height=168.2±6.7 cm, mass=62.6±9.3 kg, age=20.5±2.8 years) or intervention group n=16, height=169.8±6.3cm, mass=66.2±12.1kg, age=20.7±2.8 years). **Interventions:** Each group performed 5 DLS trials, controlled for depth and speed, before and after an AF intervention. The AF intervention consisted of verbal and visual cues to correct MKD. The control group did not receive AF. Kinematic/kinetic and EMG data were collected using electromagnetic tracking and surface EMG systems, respectively. **Main Outcome Measures:** Dependent variables were peak knee valgus and moment, hip muscle activation (Adductor, Gluteus Maximus, Gluteus Medius) and co-activation ratio. The co-activation ratio was computed as the sum of the average EMG amplitude of the abductors (gluteus maximus and medius) divided by the average EMG amplitude of the adductor for each trial. Change scores were calculated (post-intervention minus pre-intervention) for dependent variables and independent samples t-tests were used to determine differences between groups ($\alpha \leq 0.05$). **Results:** There was a change in peak knee valgus angle in the intervention compared to control group, with a decrease in the intervention group after AF ($t_{(1,30)} = -2.35$, $P = 0.03$; Control: Pre: -10.3° ± 7.4, Post: -10.3° ± 7.5; Intervention: Pre: -11.2° ± 6.6, Post: -9.9° ± 8.1). Adductor activation also changed with a decrease in the control group compared to intervention group ($t_{(1,29)} = -2.151$, $P = 0.04$; Pre-Control: 32.2% MVIC ± 25.6, Post: 28.7% ± 21.9; Pre-Intervention: 24% ± 14.8, Post: 25.1% ± 16.6). No differences in change scores were observed in co-activation ratio ($P$=0.22), Gluteus Maximus ($P$=0.59), Gluteus Medius ($P$=0.15), or knee valgus moment ($P$=0.188) after AF. **Conclusions:** AF appears to be an effective technique for decreasing knee valgus angle and may be useful in ACL injury prevention. However, neuromuscular mechanisms for decreasing knee valgus angle were not determined as we observed no changes in hip muscle activation, co-activation, and knee valgus moment in the intervention group.

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**Postural Sway And Neuropsychological Test Performance Following An Acute Bout Of Soccer Heading**

McHugh LV, Glutting JJ, Kaminski TW: Athletic Training Research Laboratory, University of Delaware, Newark, DE

**Context:** Soccer is a contact sport and therefore the participants risk injury, including head injuries. Interestingly, the activity most frequently associated with concussions is the act of heading the ball. **Objective:** The purpose of this study was to determine if there are any changes in concussion symptoms, neuropsychological test performance, and balance after an acute bout of purposeful soccer heading in players with and without prior history of concussion. **Design:** A pretest-posttest groups design. **Setting:** Soccer heading analysis occurred in a climate-controlled athletic fieldhouse, while balance and neuropsychological testing (NP) took place in an athletic training research laboratory. **Patients or Other Participants:** A total of 28 elite level female soccer players (age = 19.6 ± 0.96 years, mass = 60.4± 5.3 kg, and height = 163.6 ± 6.4 cm) participated in this project. Subjects were divided into 4 groups dependent on their concussion history: CONT = no concussion/simulated headers, EXP1 = no concussion/heading, EXP2 = 1-2 concussions/heading, EXP3 = > 3 concussions/heading. **Interventions:** All subjects completed a baseline Concussion Symptom Checklist (CSC), a computerized neuropsychological test (ImPACT), and a series of balance tests using the Balance Error Scoring System (BESS) prior to performing the first soccer heading session (*rotational* or *linear* heading). During this session they performed 15 purposeful "headers" over a 15 minute time frame. Afterwards, the subject repeated the baseline tests described above. Following 7 days, subjects returned for another heading session (*rotational* or *linear* heading) utilizing similar test procedures. **Main Outcome Measures:** Group status served as the independent variable, while CSC score, BESS score, and the 5 ImPACT composite scores were the dependent measures. A one-way, repeated measures ANOVA was used to determine if differences existed between groups and test sessions. **Results:** Interestingly, post-heading (but not attributed to either *linear* or *rotational* heading) CSC scores on day 1 decreased regardless of group status as reflected in a significant (p=.025) time main effect (pre = 4.0±5.7 vs post = 3.8±7.3). There were no significant differences in BESS scores (errors) pre vs post heading in any of the groups (CONT 12.4±5.1 vs 12.0±7.2 *linear* & 9.7±5.9 *rotational*; EXP1 12.0±4.0 vs 13.2±6.1 *linear* & 17.2±58.7 *rotational*; EXP2 11.8±6.0 vs 14.2±9.0 *linear* & 11.2±6.3 *rotational*; EXP3 15.8±6.3 vs 16.5±7.6 *linear* & 16.0±7.4 *rotational*). There were no significant differences pre to post test in the composite scores of the ImPACT test. **Conclusions:** Using soccer balls projected at speeds similar to that seen in competitive soccer and headed by a group of highly skilled players does not appear to adversely affect variables commonly measured in head injured subjects. Additionally, those with a history of concussion do not appear to be affected any more than those without a history during this acute heading task. This project is funded by a grant from the University of Delaware Women's Studies Program.

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**Effect Of Elastic Versus Plastic Wrap On Quadriceps Interface And Intramuscular Tissue Temperatures Following A Cycling Exercise Bout**

Jedlicka AD, Watkins CG, Brucker JB: University of Northern Iowa, Cedar Falls, IA

**Context:** In many instances ice bags are secured after physical activity using either elastic or plastic wraps. Because of the different breathability and insulating properties of these two materials it can be hypothesized that cooling efficacy could be affected when applied after a cardiovascular workout. **Objective:** Compare the effect of securing an ice bag using elastic wrap versus plastic wrap on interface (IF) and intramuscular (IM) tissue temperatures following exercise. **Design:** Crossover trail **Setting:** Laboratory. **Patients or Other Participants:** Eighteen physically active male participants (age= 21.8 ± 1.8 yrs, ht= 182.1 ± 5.7 cm, mass= 84.1 ± 11.8 kg, skinfold= 25.5 ± 5.4mm) in accordance with university IRB. **Interventions:** After stationary cycling for 25-minutes at 70-80% of a Karvoven predicted THR a 1 kg ice bag was secured to each anterior thigh. Independent variables were wrap (Elastic & Plastic) and time (Baseline, 1-, 5-, 10-, 15-, 20-, 25-, 30-, 35-, 40-, & 45-minutes) during cooling. **Main Outcome Measures:** Quadriceps IF and IM (2 cm + ½ skinfold) temperatures to the nearest 0.1ºC. Repeated measures ANOVAs at *a priori* of .05 were performed on the IF and IM separately. Tukey-Kramer MC tests were used when necessary. **Results:** The IF temperatures were not affected by wrap ($P$= .76), and did cool across time ($F_{10,170}$= 211.4, $P$ < .001, MSE=9.5). Baseline (32.9 ± 0.9ºC) and 1-min (31.7 ± 0.9ºC) were similar, and greater than the others with each subsequent temperature being less than the previous until the end of the study (45-min: 10.6 ± 4.7ºC;).

Likewise IM temperatures were not affected by wrap (*P*= .95), which also cooled across time ($F_{10,170}$=96.4, P < .001, MSE=5.9). The IM temperatures at baseline (37.4 ± 0.9 ºC), 1-min (37.4 ± 0.3 ºC), and 5-min (35.9 ± 1.6 ºC) were similar and warmer than the rest. Additionally, the IM 10-min (34.0 ± 3.1 ºC) and 15-min (32.7 ± 3.7 ºC) temperatures were approximately the same. Finally, the last two IM measures (40-min: 27.2 ± 4.9 ºC & 45-min: 26.2 ± 4.9 ºC) were also considered similar to each other. The IM temperatures between the 15-min and 40-min times continually cooled. **Conclusion:** The choice of whether to use an elastic or plastic wrap when securing ice bags following a cardiovascular workout should not be influenced by the suspected different breathability or insulating properties regardless if superficial or deep cooling is indicated.

# Free Communications, Poster Presentations: Master Poster Awards

Wednesday, June 23, 2010, 8:00AM-12:00PM, Grand Hall, authors present 11:00AM-12:00PM

**A Strength And Agility Training Program Reduces Knee Valgus Angle At Initial Contact**

McCann R, Onate JA, Greska E, Cortes N, Van Lunen B: Old Dominion University, Norfolk, VA

**Context:** Researchers have attempted to determine the effects of strength, flexibility, agility, and plyometric training, as well as expert feedback on biomechanical risk factors for anterior cruciate ligament (ACL) injuries. Currently, the literature lacks information regarding athletes' ability to retain adaptations made during programs designed to reduce biomechanical risk factors for ACL injuries. **Objective:** To determine the effects of a 10-week strength and agility program on lower extremity kinetics and kinematics of collegiate female soccer players immediately following training and after a 11-week retention period. **Design:** Experimental. **Setting**: Controlled Laboratory. **Participants:** Ten NCAA Division I female soccer players (19.1± 0.9years; height=1.68±0.1meters; mass= 60.4±7.1Kg) free of lower extremity injury at time of participation. **Interventions:** Subjects performed a running stop-jump task at pre training, after 10-weeks of training (post-training), and after an 11-week retention time from post-training evaluation to assess lower extremity biomechanics. The 10-week training program consisted of resistance training two times per week and field training, consisting of plyometric, agility, and speed drills, two times per week. A Certified Strength and Conditioning Specialist provided consistent augmented feedback throughout the training. Kinematic and kinetic data were collected during 5 trials of a running-stop task with an eight-camera high-speed system sampling at 270Hz (VICON Motion System), and force plates sampling at 1080Hz (Bertec). **Main Outcome Measure(s):** The independent variable of this study was time (pre-training, post-training, and retention). Dependent measures of hip and knee flexion, abduction, and rotation and ground reaction forces (posterior and vertical) were obtained at initial contact, peak vertical and posterior ground reaction forces, and peak stance (Max). Separate repeated measures ANOVA was performed to assess differences between testing times (pre, post, and retention). Statistical significance was set *a priori* at p<0.05. **Results:** There was a main effect for knee abduction angle at initial contact ($F_{(2, 18)}$=4.182, p=0.032). Pairwise comparison revealed that participants changed from an abduction/valgus knee position at pre-test (-2.2±9.3°) to an adduction/varus knee position at post-test (0.9±4.0°) at initial contact (p=.014, d=0.33). No differences were observed for pre to retention (-1.1±3.6°) or post to retention in knee abduction/valgus, *p*>0.05. There were no other statistical differences at any time instance for any dependent measure. **Conclusions:** The primary finding of this study was that the intervention program positively affected frontal plane knee alignment at initial contact during the running stop-jump. Our current study found an improvement in a theorized biomechanical risk factor for ACL injuries at a time in which the injuries are most likely to occur. Yet, the lack of a retention effect in any variable warrants further consideration in how long the effects remain. Future studies should utilize training programs should evaluate the long-term effects of such prevention programs.

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**Effect Of Patellofemoral Pain Syndrome On Neuromuscular Control On The Hip And Knee During Dynamic Postural Control**

Goto S, Aminaka N, Gribble PA: University of North Carolina at Chapel Hill, Chapel Hill, NC, and University of Toledo,Toledo, OH

**Context:** Alteration in hip and knee muscle activation and excessive knee valgus angle have been suggested as contributors to patellofemoral pain syndrome (PFPS). However, a limited number of studies have examined hip and knee muscle activations and frontal plane kinematics with conflicting results. **Objective:** To examine the differences in knee valgus angle and hip and knee muscle activation between subjects with and without PFPS during the star excursion balance test (SEBT). **Design:** Case-control study. **Setting:** Research laboratory. **Patients or Other Participants:** Twenty eight subjects volunteered for this study (14 PFPS: Age=21.07±3.27yrs; Ht= 172.09±10.26cm; Mass= 69.96±9.05kg; 14 Control: Age= 20.93±3.00yrs, Ht= 170.18 ±8.94cm, Mass= 70.25 ±8.57kg). Subjects with PFPS reported a minimum 2 months of anterior or lateral knee pain with walking, running, ascent and descent during stair climbing, kneeling, squatting, and sitting for long periods of time. **Interventions:** Subjects performed 5 anterior reaches on the SEBT. Maximum voluntary isometric contraction (MVIC) were performed for 5 seconds in the following muscles: gluteus medius (GMed), gluteus maximus (GMax), adductor longus (AD), and vastus medialis (VMO). Joint angle was assessed with an electromagnetic tracking system. Muscle activation during the MVIC and the SEBT were recorded using surface EMG. **Main Outcome Measures:** Knee valgus angle at the maximum touch-down during the SEBT task, and total knee valgus excursion (from beginning of the test to touch-down) were collected and averaged across 5 trials. Integrated EMG (iEMG) of GMed, GMax, AD, and VMO during the SEBT were averaged and normalized to the mean iEMG of the MVIC (%MVIC). Anterior reach distance during the SEBT was averaged and normalized to leg length (%MAXD). Independent t-tests were performed for each dependant variable to analyze the group differences. Significance was set *a priori* at p<.05. Cohen's *d* was used to represent effect size. **Results:** The PFPS group demonstrated greater knee valgus angle at touch-down ($t_{1,26}$=-2.73, p=.011; PFPS=1.95±9.93°, Control=11.69±8.92°; *d*=1.03) and significantly greater knee valgus excursion ($t_{1,26}$= -2.44, p=.022; PFPS=-2.27±10.28°, Control =7.08±10.01°; *d*=0.92) during the SEBT. Additionally, significantly greater VMO EMG ($t_{1,26}$=2.19, p=.04; PFPS= 132.48± 77.20% MVIC, Control= 84.58± 27.22% MVIC; *d*=0.83) and AD EMG ($t_{1,26}$=2.28,p=.031; PFPS= 48.36% ±18.44% MVIC, Control=

33.69 ±15.14%MVIC; *d*=0.87) were observed in subjects with PFPS compared to the control subjects. Finally, normalized reach distances were significantly shorter in PFPS group compared to the healthy group ($t_{1,26}$ = -2.60, p=.014; PFPS= 66.17±5.0%MAXD, Control= 70.84±4.40% MAXD; *d*=-0.99). **Conclusion:** PFPS demonstrated more knee valgus angle and increased AD and VMO activation while also demonstrating reduced dynamic postural control compared to Control subjects. These results suggest that deficits in knee valgus and hip and knee neuromuscular control exist in PFPS subjects during a dynamic task. Clinicians may need to address frontal plane movement and correct hip and knee muscle activation for rehabilitation of PFPS.

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**Comparison Of Reactive Knee Stiffening Strategies Between Sexes**

Hinsey ML, Swanik CB, Thomas SJ, Rudolph KS, Kaminski KS, Chang B, Department of Health, Nutrition, and Exercise Science, Human Performance Laboratory, University of Delaware, Newark, DE, and Department of Physical Therapy, University of Delaware, Newark, DE

**Context:** Our understanding of joint stability is limited regarding knee muscle stiffening strategies in response to unanticipated external loads. Knee stiffness is suggested to differ between sexes, potentially explaining the gender bias related to knee injuries. Greater incite may be provided by investigating strategies of both sexes to reactively stiffening the knee against perturbations. **Objective:** To determine knee stiffness values between sexes in relaxed and pre-contracted states with and without volitional reaction to an external perturbation. **Design:** Posttest-only comparison group **Setting:** This study was performed in a controlled laboratory setting. **Participants:** Forty (20 males, 20 females) healthy, college-aged participants (20.73±1.98 years, 174.49±8.97cm, 72.31±13.03kg) with no current injury or previous surgery to the dominant leg. **Interventions:** The independent variables were sex, contraction state prior to the perturbation (relaxed, pre-contracted to 30% quadriceps MVIC) and response (reaction or no reaction). All stiffness measures were collected on a custom-built Stiffness and Proprioception Assessment Device (SPAD). Participants were positioned in the SPAD with the dominant knee flexed to 30°. Subjects remained relaxed or contracted their quadriceps to 30% MVIC. Participants were instructed prior to the randomly-timed knee flexion perturbation (Excursion = 40°, Velocity = 75°/s, Acceleration = 1000°/s$^2$) if they were to react once they began to feel their leg move or not. Each condition contained five trials. Stiffness values were calculated at 4° and 40° of excursion. Data were processed in a customized LabVIEW software program (National Instruments, Austin, TX). A three-way ANOVA with post-hoc analysis was used to determine differences between gender and between conditions. **Main Outcome Measures:** Knee stiffness measurements were calculated as torque (Nm) / position (degrees). Stiffness values were body mass-normalized. **Results:** Four-degree stiffness values were significantly ($p<0.05$) higher in males (stiffness = 0.073±0.003 Nm/deg/kg) than females (stiffness = 0.064±0.003 Nm/deg/kg). No gender differences were observed for total stiffness. Contraction and reaction interactions were observed for both 4° and total stiffness (4° relaxed, no reaction = 0.057±0.002 Nm/deg/kg, 4° relaxed, reaction = 0.063±0.002 Nm/deg/kg, $p<0.05$; total pre-contracted, no reaction = 0.006±0.001 Nm/deg/kg, total pre-contracted, reaction = 0.048±0.002 Nm/deg/kg, $p<0.05$; total relaxed, no reaction = 0.001±0.000 Nm/deg/kg, total relaxed, reaction = 0.054±0.002 Nm/deg/kg). **Conclusions:** Upon differing instructions, all individuals can greatly modify knee stiffness levels in response to unanticipated loads, which may aid in the design of specific exercises in prevention and rehabilitation programs for knee injuries. Increased male stiffness over the initial short-range of 4° suggests a potential tissue level biochemical difference in muscle fiber/collagen architecture or resting tone. The lack of significant sex differences in total stiffness (40°) suggests females have an equal capacity resist large excursions from unanticipated external knee loads through stiffness regulation if body mass is taken into consideration.

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**Soldier Step And Activity Counts During A Single Road March: A Pilot Study**

Stoehr SM, Williams KW, Kostek MC, Dompier TP, Mensch JM: Department of Physical Education and Athletic Training, University of South Carolina, Columbia, SC; Experimentation and Analysis Element, Fort Jackson, SC; Department of Exercise Science, School of Public Health, University of South Carolina, Columbia, SC

**Context:** Stress fractures are a major contributor to the overall musculoskeletal burden faced by Soldiers during Basic Combat Training (BCT). It has been speculated that over striding by shorter Soldiers while marching is a risk factor for stress fracture development with females having the highest incidence. **Objective:** The purpose of this study was to compare step and activity counts of tall and short female and male Soldiers during a typical 16.1 kilometer road march. **Design:** Prospective observational. **Setting:** A United States Army Training Center located in the Southeast United States from 2008 to 2009. **Patients or Other Participants:** Volunteers included 6 short(SF) and tall female(TF) and 5 short(SM) and tall male(TM) Soldiers between the ages of 18 and 42. A TF Soldier was excluded at baseline measurement due to an injury, and 2 SF and 3 SM Soldiers declined to participate on the day of the march. Additionally, a SF dropped out and one accelerometer on a TM malfunctioned leaving: 3-SF (height =151.7±5.9 cm, weight =58.1±4.5 kg), 5-TF (height =171.0±6.2 cm, weight =71.2±6.8 kg), 2-SM (height =165.0±7.1 cm, weight =67.0 ±.04 kg), and 4-TM (height = 185.8±7.5 cm, weight =99.1±21.8 kg) Soldiers. **Inter-ventions:** The independent variable was group status determined by height measurements taken at baseline. Soldiers who were less or greater than 1 standard deviation of the national mean were categorized as short or tall by gender, respectively. Only Soldiers who met these criteria were recruited for participation. **Main Outcome Measures:** The dependant variables were the mean step and activity counts measured with GT1M accelerometers (Actigraph, Pensacola, FL) during a 16.1 kilometer road march. The accelerometers were placed over the right anterior superior iliac spine. Data were truncated by 10 minutes at the start and end of each leg of the march to account for different starting positions. One-way analysis of variance (ANOVA) was used to examine group differences in mean step and activity counts with Bonferroni adjustment for multiple comparisons ($\alpha = .05$). **Results:** The mean number of steps decreased as height increased across groups with SFs having the most 17,539.0±349.6 and the TMs having the least 13,126.3±1365.6. There were significant differences in steps between groups ($F_{3,10}$ = 17.3, $P < .001$) but activity did not differ ($F_{3,10}$ = .898, $P = .476$). Post hoc analysis revealed that TMs took less steps than SFs ($P < .001$) and TFs ($P = .002$), but did not differ from SMs ($P = .072$). **Conclusions:** Short female Soldiers took significantly more steps than tall male Soldiers during a single road march which may be a contributing factor to increased stress fracture incidence in females. Future research should examine a larger sample and correlate difference with injury data.

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**Relationship Between Transcranial Magnetic Stimulation And Percutaneous Electrical Stimulation In Determining The Quadriceps Central Activation Ratio**

Norte GN, Pietrosimone BG, Hart JM, Hertel J, Ingersoll CD: University of Virginia, Charlottesville, VA; University of Toledo, Toledo, OH; Central Michigan University, Mount Pleasant, MI

**Context**: Quadriceps central activation ratio (CAR) is commonly evaluated with various forms of a percutaneous electrical stimulation used to elicit muscle contraction of inhibited musculature. Pain during the electrical stimulation is a common limitation that may affect accrual and retention of study participants. Transcranial magnetic stimulation (TMS) has recently been reported to elicit supramaximal contractions and may provide a novel relatively non-painful method for assessing quadriceps CAR. **Objective:** To determine the relationship between quadriceps CAR derived from a superimposed burst of electrical stimulation ($CAR_{SIB}$) and TMS ($CAR_{TMS}$) in healthy subjects as well as assessing reliability of both techniques. **Design:** Descriptive laboratory study. **Setting:** Laboratory. **Patients or Other Participants:** Nineteen healthy subjects (5 Males, 14 Females, 23.7± 4.8 yrs, 66.8±10.0 kg, and 170.1±7.0 cm) volunteered. **Intervention(s)**: Both methods ($CAR_{SIB}$ and $CAR_{TMS}$), were assessed at days 1, 14 and 28 for all subjects by the same investigator. The order in which each method was used to evaluate CAR was counterbalanced between subjects. Both measures were assessed at 90° of knee flexion. **Main Outcome Measure**: Volitional quadriceps activation calculated with the CAR for both methods, which is expressed as a percentage of complete activation. After testing skewness, 3 separate, Spearman rank correlations were used to assess the relationship between methods at all 3 time points. Three separate, Bland-Altman plots were used to evaluate the agreement between the two methods over time. Reliability was assessed comparing baseline to days 14 and 28 measurements for both methods using separate Bland-Altman plots and intraclass correlation coefficients ($ICC_{1,2}$). *A priori* levels of significance were set at $P \leq 0.05$ for correlations. **Results**: $CAR_{TMS}$ scores were higher than $CAR_{SIB}$ scores for all time points (day 1: 97±2 vs 91±8, day 14: 97±2 v 94±6, day 28: 97±1 vs 95±4). The only significant positive correlation was between $CAR_{SIB}$ and $CAR_{TMS}$ at day 14 ($r = 0.45$, $P = 0.05$). Mean CAR differences and limits of agreement (LOA) between methods were (-0.06, LOA -0.19 to 0.07), (-0.03, LOA -0.14 to 0.08), and (-0.03, LOA -0.11 to 0.05) at days 1, 14 and 28 respectively. Intersession reliability was strong for $CAR_{SIB}$ at day 14 ($ICC_{2,k} = 0.80$, $P$=0.001) and 28 ($ICC_{2,k} = 0.85$, $P$=0.001) from day1, while $CAR_{TMS}$ was moderate at day 14 ($ICC_{2,k}$=0.68, $P = 0.01$) and insignificant at day 28($ICC_{2,k}$=-0.68, $P = 0.86$). $CAR_{TMS}$ had smaller mean differences and LOA at day 14 (0, LOA -0.03 to 0.03) and 28 (-0.01, LOA -0.05 to 0.03) compared to $CAR_{SIB}$ (-0.02, LOA -0.11 to 0.07; -0.03,-0.09 to 0.03) **Conclusions**: This study provides evidence that $CAR_{TMS}$ and $CAR_{SIB}$ are not interchangeable assessment tools for measuring quadriceps activation, yet individually may be reliable measures of muscle activation.

# Free Communications, Poster Presentations: Doctoral Poster Awards

Wednesday, June 23, 2010, 8:00AM-12:00PM, Grand Hall, authors present 11:00AM-12:00PM

**Development And Validation Of A FIELD-Based Prediction Tool To Identify High ACL Injury Risk Female Athletes**

Myer GD, Ford KR, Khoury J, Succop P, Hewett TE: Cincinnati Children's Hospital Medical Center, Cincinnati, OH; Rocky Mountain University of Health Professions, Provo, UT; University of Cincinnati, Cincinnati, OH

**Context:** Prospective measures of high knee abduction moment (HIGHLOAD) during landing identify female athletes at increased risk for ACL injury. Laboratory driven (LAB-based) measurements predict HIGHLOAD with high sensitivity (85%) and specificity (93%). **Objectives**: To develop and validate a "clinician friendly" landing assessment tool (FIELD-based) for assessing increased ACL injury risk. The hypothesis was that clinically obtainable correlates derived from highly predictive LAB-based models would demonstrate high accuracy for determination of HIGHLOAD status. **Design:** Prospective cohort study. **Setting:** Controlled, laboratory. **Patients or Other Participants:** Seven hundred forty-four female basketball and soccer players (mean ± 1SD) (age: 13.9±2.4 years; height 159.3±8.6 cm; body mass 54.0±12.5 kg) from a county public school district were tested for anthropometrics, strength and landing biomechanics. These data were utilized for the regression model variable selection and optimization for HIGHLOAD prediction. To validate the HIGHLOAD prediction model, female basketball, soccer and volleyball players (N=20; Age: 15.9±1.3 years, height: 163.6±9.9 cm; body mass: 57.0±12.1 kg) were tested using 3-dimensional (3-D) motion analysis and FIELD-based techniques simultaneously. **Interventions:** Multiple logistic regression was used to examine predictors of HIGHLOAD (a surrogate for ACL injury risk). Pearson correlation was used to determine clinically feasible correlates of the LAB-based predictors to be utilized for FIELD-based landing assessment and included in the FIELD-based prediction nomogram. FIELD-based methods were validated against LAB-based measures using within and between method reliability (intraclass correlations (ICC) and Bland-Altman Plots) and sensitivity and specificity (logistic regression). **Main Outcome Measure:** HIGHLOAD landing status (>21.7Nm external knee abduction) **Results:** The FIELD-based prediction model included (Odds Ratio: 95% confidence interval) knee valgus motion (1.43:1.30-1.59/ cm), knee flexion range of motion (0.98: 0.96-1.01/ deg), body mass (1.04: 1.02-1.06/ kg), tibia length (1.38: 1.25-1.52/ cm) and quadriceps to hamstrings ratio (1.70: 1.06-2.70/ %) and predicted HIGHLOAD status with 73% sensitivity, 70% specificity and C statistic of 0.81. The within variable analysis showed excellent inter-rater reliability for all variables using both methods, with ICCs that ranged from moderate to high, 0.60 to 0.97. In addition, moderate to high agreement was observed between LAB-based and FIELD-based measures with ICCs ranging from 0.66 to 0.99. Bland-Altman plots confirmed that each variable provided no systematic shift between LAB and FIELD-based methods and no association between difference and average. The LAB-based method also demonstrated excellent prediction accuracy of HIGHLOAD status (sensitivity 63%, specificity 83% and area under the ROC curve of 0.91). **Conclusions:** Prior reports indicate that High ACL injury risk female athletes who demonstrate HIGHLOAD are more responsive to the benefits of neuromuscular training. Clinically feasible FIELD-based measurements predict HIGHLOAD with high sensitivity and specificity. The FIELD-based assessment tool may facilitate high-risk athletes entry into appropriate interventions that will have greater potential to reduce their injury risk.

**Subchondral Bone Contusions Associated With ACL Injury Do Not Alter Knee Frontal Plane Biomechanics**

Thomas AC, Palmieri-Smith RM: University of Michigan, Ann Arbor, MI

**Context:** Approximately 80% of all anterior cruciate ligament (ACL) injuries are accompanied by a lateral tibiofemoral compartment bone bruise suffered at the time of injury. It is suggested that persons with a lateral bone bruise report greater pain during weight bearing following injury than those without a bone bruise. Further, individuals with a lateral bone bruise reportedly alter their knee frontal plane biomechanics to alleviate pain, subsequently reducing lateral tibiofemoral compartment loading and increasing the moment experienced medially. With an increase in this external knee adduction moment (KAM) purportedly contributing to post-traumatic knee osteoarthritis develop-ment/progression, this gait adaptation appears hazardous. However, no in vivo biomechanical data exist to confirm the relationship between lateral bone bruising associated with ACL injury and an increase in the external KAM. **Objective:** To determine if lateral bone bruising following ACL injury precipitates an increase in the external KAM. **Design:** A cross-sectional, case-control study. **Setting:** This study was performed in a controlled laboratory setting. **Patients or Other Participants:** Nine volunteers with an ACL injury (21.11±4.11 years, 1.77±0.09 m, 77.76±17.01 kg), eleven with an ACL injury and a lateral bone bruise (18.27±5.53 years,1.74±0.10 m, 70.41±13.30 kg), and nine healthy controls (20.11±1.83 years, 1.73±0.09m, 66.97±10.25 kg) participated. **Interventions:** Knee frontal plane biomechanics were recorded as participants performed three walking trials at 1.1 m/s (±5%), stepping onto a force platform located in the field of view of a motion capture system. **Main Outcome Measures:** Peak KAM was calculated during the first half of stance using a standard inverse dynamics approach, normalized to participant body mass (kg) and height (m), and converted to represent an external moment. Biomechanical data were averaged across trials and analyzed via one-way ANOVA. **Results:** The external KAM did not differ between groups (ACL: 0.14±0.06; ACL bone bruise: 0.19±0.10; control: 0.18±0.08; *P*=0.39). **Conclusions:** Individuals with an ACL injury and concomitant lateral bone bruise did not demonstrate a significantly greater external KAM when compared to both ACL-injured individuals without lateral bone bruising as well as healthy persons. Thus, while increased medial knee joint loading is a suggested contributor to knee joint degeneration, it does not appear that lateral bone bruising contributes to this hazardous increase in the external KAM. Further research is needed to determine, if any, the precise consequences of lateral bone bruising following ACL injury. This research was supported by grants from NFL Charities and Rackham School of Graduate Studies.

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**Lower Extremity Kinetic Differences Are Present Between Prepubescent Males And Females During Unanticipated Sidestep Cutting**

Jackson KR, Hertel J, Hart JM, Kerrigan DC, Ingersoll CD: University of Virginia, Charlottesville, VA; University of Toledo, Toledo, OH; Central Michigan University, Mt. Pleasant, MI

**Context:** The anterior cruciate ligament (ACL) gender bias becomes apparent after age 12 potentially related to maturation changes. Information regarding the biomechanical patterns of prepubescent athletes during dynamic tasks, when ACL injuries commonly occur, is limited. However it is important in understanding the role of physical development in ACL injury risk. **Objective:** To compare lower extremity biomechanics of prepubescent male and female athletes during unanticipated sidestep cutting (SSC). **Design:** Cohort study. **Setting:** Motion analysis laboratory. **Patients or Other Participants:** Nineteen participants (10M: 10.0±2.1yrs, 150±14.4cm, 38.5±7.0 kg; 9F: 9.4±1.1yrs, 144±8.0cm, 35.4±3.0kg) classified as prepubescent by the Pubertal Maturation Observation Scale. All actively participated in an organized sports that involved running, jumping and SSC and had no lower extremity injury within the previous 6 months. **Intervention(s):** The independent variable was group (male, female). Participants ran and reacted to a custom software program projected onto a screen that randomly signaled 1 of 3 tasks: a forward run, left cut or jump-stop. Five trials of the SSC where the subject ran between 3.5-4.5 m/s were averaged and used for analysis. Data were collected for the right limb and inverse dynamics was used to quantify external joint moments. **Main Outcome Measures:** Dependent variables were mean peak 3-dimensional hip and knee kinetics and kinematics during the stance phase of SSC. Two separate one-way MANOVAs comparing gender for hip and knee kinematic variables were run. The kinetic data failed the tests for normality (skewness and kurtosis > 1) therefore individual Mann-Whitney U Tests were run for each kinetic variable. Standardized effect sizes with 95% confidence intervals were calculated when the independent samples test revealed a significant difference between groups. Descriptive data is reported as the median (interquartile range [IQR]: 25$^{th}$, 75$^{th}$). **Results:** There were no significant kinematic differences between groups (*P*>.05). Females had a significantly (Z= -2.213, *P*=.027) smaller hip flexion moment than males (F: 1.62 [1.06,2.00] Nm/kgm; M: 3.45 [1.64,4.72] Nm/kgm) with a strong effect size d=-1.3(-2.27,-0.19). The female group also had a significantly smaller hip adduction moment (Z=-2.694, *P*=.006) than the male group (F: 0.976 [0.523,1.11] Nm/kgm; M: 1.58 [1.19,2.36] Nm/kgm) with strong effects d= -1.33(-2.28,-0.26). Additionally, females had a significantly (Z=-2.276, *P*=.023) smaller knee extension moment than males (F: -0.342 [-3.77,-3.14] Nm/kgm; M: -0.506 [-1.24,-.399] Nm/kgm) as well as significantly (Z=-2.309, *P*=.021) smaller knee internal rotation moments than males (F: 0.12 [0.104,0.132] Nm/kgm; M: 0.161 [0.135,0.212] Nm/kgm). The knee extension moment had a strong effect at d=1.21(0.12-2.18). **Conclusions:** Lower extremity kinetic differences are present between males and females prior to the onset of puberty. Prepubescent females may present neuromuscular control deficits of the gluteals and hamstrings when managing external loading during SSC as indicated by smaller external joint moments.

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**Injection Of The Lateral Ankle Ligaments With Local Anesthetics Does Not Inhibit Muscle Activity**

House AJ, Abt JP, Stone DA, Akins JS, Pederson JJ, Keenan KA, Lephart SM: University of Pittsburgh, Neuromuscular Research Laboratory, Pittsburgh, PA

**Context:** The use of local anesthetics to return an athlete to play following an ankle inversion sprain is a common practice for pain suppression, yet the impact of such treatment on motor function remains inconclusive. **Objective:** To determine if the muscle activation patterns of the peroneus longus (PL), tibialis anterior (TA), and medial gastrocnemius (MG) during a running task are suppressed following a lidocaine injection to the anterior talofibular (ATF) and calcaneofibular (CF) ligaments and if a dose-response threshold exists. **Design:** A single-blind, randomized controlled trial. **Setting:** A University sports medicine research laboratory. **Patients or Other Participants:** A total of 14 recreationally active male subjects (age: 24.8 ± 2.9 years, height: 177.0 ± 6.0 cm, mass: 77.7 ± 6.7 kg) participated. **Interventions:** The subjects performed a series of 10 gait cycles on a treadmill at a speed of 3.35 $m \cdot s^{-1}$. The running trials were performed under

five injected conditions to the ATF and CF: 1ml saline, 1ml lidocaine, 3 ml saline, 3ml lidocaine, or no injection. A closed basketweave was used to tape the ankle for each condition following the injection as part of standard clinical practice. Electromyographic patterns of the PL, TA, and MG were collected during the running trials. **Main Outcome Measures:** Pre-activation mean amplitude and integrated EMG (within 100 ms prior to initial contact) and loading phase mean amplitude and integrated EMG (50 ms to 200 ms) were calculated. One-way repeated measures ANOVA tests were used to analyze the dependent variables ($p < 0.05$). **Results:** No significant injection differences were demonstrated in pre-activation mean amplitude for the TA (CV: 22.6-41.4%, $p = 0.855$), PL (CV: 39.1-74.0%, $p = 0.556$), MG (CV: 35.1-47.2%, $p = 0.622$) or loading phase mean amplitude for the TA (CV: 45.2-130.2%, $p = 0.239$), PL (CV: 51.0-144.0%, $p = 0.382$), MG (CV: 23.3-46.9%, $p = 0.659$). No significant injection differences were demonstrated in pre-activation integrated EMG for the TA (CV: 25.8-52.0%, $p = 0.280$), PL (CV: 43.2-69.2%, $p = 0.439$), MG (CV: 37.2-47.8%, $p = 0.766$) or loading phase integrated EMG for the TA (CV: 59.2-127.0%, $p = 0.224$), PL (CV: 58.0-142.8%, $p = 0.349$), MG (CV: 24.7-55.0%, $p = 0.321$). **Conclusions:** The results of this study suggest the clinical use of lidocaine to diminish pain from an ATF or CF ligament sprain does not alter muscle activity of the PL, TA, or MG during the running task. The results also suggest there are no muscle activity differences between a 1ml and 3ml lidocaine injection indicating the maximum can be used for pain control.

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**Effects Of Transcutaneous Electrical Nerve Stimulation On Peak External Knee Flexion Moment And Knee Flexion Angle During Gait In Patients With Tibiofemoral Osteoarthritis**

Pietrosimone BG, Saliba SA, Hart JM, Hertel J, Sauer LD, Kerrigan DC, Ingersoll CD: University of Toledo, Toledo, OH; University of Virginia, Charlottesville, VA; Central Michigan University, Mount Pleasant, MI

**Context:** Decreased quadriceps activation, associated with tibiofemoral osteoarthritis (TFOA) has been suggested to contribute to altered gait mechanics, including decreased peak external knee flexion moment (KFM) and peak knee flexion angle (KFA). Recently, disinhibitory transcutaneous electrical nerve stimulation (DTENS) has been reported to increase quadriceps activation. It remains unknown whether DTENS affects peak quadriceps related moments and angles during gait. **Objective:** Determine if sensory DTENS augmented with therapeutic exercise and worn during daily activities for a 4-week period will alter KFM and KFA, compared to receiving placebo DTENS and exercise, or receiving exercise only. **Design:** Single blinded, randomized controlled trial. **Setting:** Motion analysis laboratory. **Participants:** Thirty-six participants with TFOA were stratified by Kellgren-Lawrence score and baseline quadriceps activation, and randomized into 3 groups *(*DTENS: 6M/6F, 59.8±10.9yrs, 28.6±4.89 BMI; Placebo: 4M/8F, 6.2±11.5yrs, 29.5±9.8BMI; control: 5M/7 F, 57.9±12.2yrs, 28.6±5.6 BMI). **Interventions:** All groups participated in 12 supervised, unilateral lower extremity exercise sessions over 4 consecutive weeks. DTENS and placebo groups wore the intervention on the injured knee during exercise sessions and daily activities for 4 weeks. A 3-dimensional Vicon motion analysis system with 4 AMTI force places embedded in a 30m runway was used to acquire kinetic and kinematic data. **Main Outcome Measures:** Three peak KFM and KFA measurements in the involved leg were averaged before and after the 4-week intervention. KFM, KFA and walking speed were expressed as Nm/Kgm, degrees and m/s, respectively. Two separate, 2x3 repeated measures analyses of variance (ANOVA) were used to determine differences in peak KFM and KFA between intervention groups (DTENS, Placebo, Control) over time (baseline, post-intervention). A 2x3 repeated measures ANOVA was used to determine differences in walking speed between groups over time. An *a priori* significance level was set at $P \leq 0.05$. **Results:** All groups significantly increased in walking speed from pretest (DTENS 1.2±0.2, Placebo 1.2±0.3, Control 1.3±0.2) to posttest (DTENS 1.3±0.2, Placebo 1.3±0.2, Control 1.3±0.1; $P \leq 0.001$), yet no differences were found between groups ($P = 0.25$). After correcting for changes in speed, using a 2x3 repeated measures analysis of covariance with change in speed as the covariate, no significant differences were found between groups (KFM: $P = 0.85$, KFA: $P = 0.81$) or over time (KFM: $P = 0.95$; KFA: $P = 0.76$) for kinematics and kinetics. There were no trends for group means over time in KFM (DTENS 0.13±0.17 vs 0.10±0.08, Placebo 0.11±0.16 vs 0.19±0.19, Control 0.07± 0.12 vs 0.17±0.29) or KFA (TENS 20.3± 6.7 vs 20.2±12.5, Placebo 18.2±8 vs 19.3±11.4, Control 16.5± 5.3 vs 20.4±4.7). **Conclusions:** DTENS in conjunction with therapeutic exercise over a 4-week period does not affect peak KFM and KFA during gait in TFOA patients. Specialized training may be necessary to alter gait parameters in addition to disinhibitory interventions in patients with quadriceps activation deficits. This study was partially funded by the NATA Foundation Doctoral Research Grant Program and a grant from the American Physical Therapy Association's Orthopedic Section.

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**Significance Of Wound Location On The Lower Leg When Using A Standardized Infliction Model And Semiautomatic Digital Imaging Method To Assess Acute Wound Healing**


Beam JW, Buckley BD: University of North Florida, Jacksonville, FL


**Context:** Standardized protocols are needed to assess the effectiveness of dressings on wound healing. However, wound infliction models often do not consider the location of the wounds on the involved body area. The location of the wounds could affect healing rates and measurements based on variations within subjects. **Objective:** To determine the effects of wound location on the healing of partial-thickness abrasions on the lower leg across time. **Design:** Controlled, counterbalanced repeated-measures design. **Setting:** Research laboratory. **Patients or Other Participants:** Digital images of standardized, partial-thickness abrasions from 28 healthy collegiate volunteers, 18 females and 10 males (22.0±1.0 years; 170.67±9.49 cm; 73.61±18.05 kg). **Interventions:** A 21 X 10 cm template was placed on the lateral lower leg of each subject between the fibular head and lateral malleolus prior to infliction. The wound infliction model produced four standardized partial-thickness abrasions (2.25 cm in diameter) spaced 4 cm apart in a proximal-to-distal pattern on the lateral lower leg. Following infliction and cleansing, occlusive dressings were applied in a counterbalanced technique. Subjects returned on post-wound days 3, 5, 7, 10, and 14 for digital imaging. All imaging sessions followed standard procedures. Three digital images were recorded for each wound location. The images for the hydrocolloid dressing among all subjects were entered into Adobe Photoshop CS3 (Adobe Systems, Inc, San Jose, CA) for semiautomatic analysis of chromatic red (CR) and luminance (L). Using Microsoft Office Excel 2007 (Microsoft Corporation, Redmond, WA), CR ([100 x red]/[red + green + blue]) and L ([red + green + blue]/3) measurements were calculated. **Main Outcome Measures:** The average of the three images for CR and L in red, green, and blue color values were used for data analysis. A repeated measures ANOVA was performed to compare the four wound locations over post-wound days 3, 5, 7, 10, and 14. Tukey HSD was used for post hoc analysis. **Results:** Significant differences were found in CR(wound 1=51.52±8.90, wound 2=58.59±10.47, wound 3=55.57±9.82, and wound 4=55.17±9.04, $F_{3,24}$=5.335, P=.006). Post hoc analysis showed wound 2 produced a greater overall measure of CR compared to wound 1. L measures were non-significant (wound 1=122.43±33.92, wound 2=100.94 ±27.61, wound 3=110.95±32.61, and wound 4=112.19±29.69, P=.463). **Conclusions:** A greater measure of CR was associated with wound 2. This may be the result of physiologic and structural differences in vasculature, epidermal appendages, and tissue thickness, tension, and elasticity in the lateral lower leg within the subjects. Wound location did not affect L measures. Luminance measures and previous, high intra- and intertester reliability data suggest that the infliction model and digital imaging method may be used as a standardized protocol to assess the effectiveness of dressings on acute wound healing.

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**Perceptions Of Body Image And Prevalence Of Disordered Eating In Collegiate Female Track And Field Athletes**


Torres-McGehee TM, Monsma EV, Searson JR, Minton DM, Zachowitz K: University of South Carolina, Columbia, SC


**Context:** Revealing uniforms and intense training may predispose track and field athletes to eating disorders(ED) and body image(BI) distortion. Discrepancy between perceived (PBI) and desired body image(DBI) has been associated with a variety of maladaptive thoughts and behaviors but little is known about clothing type and proxy body image perceptions (e.g., athletes' perception of what others perceive about that athlete's body). **Objective:** Estimate prevalence of ED risk in track and field athletes by position (sprinters-S, middle distance-MD, distance-D, lean field events-LFE, non-lean field events-NLFE, multi-event-ME) and examine clothing type (daily clothing–DC, competitive uniform-CU) and proxy BI (peers-P, parents-PA, coaches-CO) interactions in discrepancy scores across positions. **Design:** Cross-sectional study. **Setting:** NCAA Division I and II institutions across the United States. **Patients or Other Participants:** Volunteer sample of female track and field athletes (n=274) [20.4±1.47yrs, 167.3±6.7cm, 62.1±11.3kg], representing 5 track and field disciplines (S:n=54; MD:n=52; D:n=75; LFE:n=47; NLFE:n=31; ME:n=15). **Interventions:** Participants self-reported height and weight and completed the Eating Attitudes Test (EAT-26) and questions regarding PBI and DBI in DC vs CU and athletes' perceptions of their P, PA, and COs' PBI and DBI in DC were answered using a gender-base BMI silhouette. EAT-26 scores estimated ED risk. A 6(position) x 2(clothing type) x 2(perceptions) ANOVA with repeated measures on the last two factors was conducted on BMI based silhouettes. A second 6(position) x 3(proxy) x 2(perceptions) ANOVA with repeated measures on the last two factors was conducted on BMI based silhouettes. **Main Outcome Measures:** Total EAT-26 scores were used to estimate prevalence for potential risk for eating disorders. BMI-based silhouettes were used to assess body image. **Results:** Prevalence for ED risk for all participants was estimated at 24.8% (95% CI: 24.8%±5.1%) and then separated into position S=20.4% (95% CI: 20.4%±10.8%), MD= 19.2% (95% CI: 19.2%±10.7%), D=28% (95% CI: 28%± 10.1%), LFE=27.7% (95% CI: 27.7%± 12.6%), NLFE=32.3% (95% CI: 32.3% ±5.2%) and ME=20% (95% CI: 20%±20.1%). Overall, results indicated no main effect, but interaction effects for perceptions (PBIvs.DBI; $p$<.01) and perceptions and discipline ($p$<0.01) were found. A clothing type x perceptions interaction effect ($p$=0.01) indicated largest body image dissatisfaction with CU (22.6vs.20.7kg/m²) compared to DC (22.4vs.20.8kg/m²). A perceptions x proxy interaction ($p$<0.01) indicated largest body image dissatisfaction from CO (22.6vs .21.2kg/m²) compared to P (22.0vs.21.6kg/m²) and PA (21.2vs.21.5kg/m²). **Conclusion:** Regardless of position, track and field athletes in general reported to be at risk for eating disorders. CU and discrepancy scores between athletes' perceptions of what coaches think their athletes look like compared to what they should look like are implicated in body dissatisfaction and should be examined further as correlates of maladaptive thoughts and behaviors.

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**Athletic Injuries Classified As Trauma At A Pediatric Hospital In 2008**

Rogers KJ, Adams J, Shah SA, O'Brien K: Alfred I duPont Hospital for Children, Wilmington, DE

**Context:** The rationale was to document trauma related athletic injuries that occurred through a pediatric emergency department (ED) for a one year period. **Objective:** To review distribution of sports and type of trauma with subsequent care. **Design:** Retrospective review of medical charts. **Setting:** Pediatric hospital trauma center. **Patients or Other Participants:** Patients between the ages of 1 – 19 years of age during 2008. **Interventions:** The E codes 884.9, 885.9, 886.0, and 917.0 were searched. All 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:** Eighty-five patients (72 males and 13 females) with a mean age of 13.3 (5.4 -19) years of age were classified as having an athletic injury trauma: (1) admitted (55); (2) transferred and admitted (21); (3) transferred (9); and (4) death (0). The trauma E code classifications were: (a) 886.0 - fall on same level from collision, pushing or shoving by or with other person in sports (46); (b) 917.0 - striking against or struck accidentally by objects or persons (30); (c) 885.9 – fall from slipping, tripping, or stumbling (5); and (d) 884.9 – fall from one level to another (4). Fifty-seven injuries occurred during competition while the remaining occurred in recreation (18), school-gym class (5), home (4), or camp activities (1). Eight people had a prior history of the same injury. The most common mechanism of injury (MOI) was player to player contact (44). The balance of MOIs were contact with playing surface (20), contact with playing apparatus (16), and no contact (5). Twenty different sports were seen in the ED with football (22), baseball (15), and basketball (12) the most frequent. Sixty-eight orthopedic injuries and 24 medical injuries occurred. Elbows (20) and head (12) were the most frequent respectively. Seven patients had both an orthopedic and medical injury. One person had 3 injuries and 10 had 2 injuries. Surgeries were orthopedic (54), trauma surgery (3), and plastic surgery (1). Internal fixation open (21) and closed (14) were the two most common Orthopedic procedures. **Conclusions:** No study to our knowledge has classified the pediatric athletic injury trauma frequency and related treatment for both orthopedic and medical injuries. This study may lead to further understanding of the prevalence of traumatic athletic injury in this population and subsequent prevention strategies.

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**Concurrent Validity Of Lysholm Scale Responses And Corresponding Performance Based Measures Of Function In Articular Cartilage Patients**

Howard JS, Mattacola CG, Lattermann C: University of Kentucky, Lexington, KY

**Context:** Self-report instruments are frequently used to evaluate patient function. Ideally responses to these instruments represent a patient's physical capabilities. Although reliability of the Lysholm Scale has been established among articular cartilage patients, concurrent validity of the scale has not been previously reported. **Objective:** To determine the validity of the 8 domains of the Lysholm relative to physical function. We hypothesized that the Lysholm domains would moderately correlate with performance based measures representing walking, squatting, and stairs. **Design:** Single-occasion cohort. **Setting:** Laboratory. **Patients:** 27 patients (age=37$\pm$7 years, height=174$\pm$11 cm, mass=90.1$\pm$20.8kg) seeking surgical intervention for knee articular cartilage defects. **Interventions:** Preoperatively, all patients completed the Lysholm followed by functional assessment utilizing the Neurocom Long Forceplate (Neurocom International, Clackamas, OR). Patients performed the following: Walk-Across, Weight Bearing Squat, Sit-to-Stand, and Step-Up-and-Over. **Main Outcome Measures:** The Lysholm domains are *Limp, Support, Locking, Instability, Pain, Swelling, Stairs* and *Squatting*. Performance variables were: *Walk-Across* speed, length, and width; *Weight Bearing Squat* percent body weight on the involved side at 0p, 30p, 60p, and 90p knee flexion; *Sit-to-Stand* weight transfer time, center of gravity sway velocity, rise force, and rise symmetry; and *Step-Up-and-Over* time, lift off force, and impact force. Spearman's rank correlations were used to determine the relationship between Lysholm domains and performance variables. **Results:** Performance measures that correlated significantly to *Limp* were *Walk-Across* length (r=-.48, p=.010), *Weight Bearing Squat* at 30p (r=-.52, p=.006), and *Step-Up-and-Over* uninvolved impact force (r=-.40, p=.040). *Support* correlated to *Walk-Across* length (r=-.38, p=.050) and speed (r= -.45, p=.017); and *Step-Up-and-Over* uninvolved limb lift off force (r=-.42, p=.030). *Locking* correlated to *Step-Up-and-Over* between limb time difference (r=.41, p=.040). *Instability* correlated to *Step-Up-and-Over* uninvolved limb impact force (r=-.44, p=.023). *Pain* correlated with *Sit-to-Stand* center of gravity sway velocity (r=.45, p=.019); and *Step-Up-and-Over* uninvolved limb impact force (r=-.44, p=.021). *Swelling* correlated to *Walk-Across* width (r=.47, p=.014) and length (r=-.46, p=.017); and *Sit-to-Stand* rise force (r=-.42, p=.035). *Stairs* correlated to *Walk-Across* length (r=.40, p=.039); *Weight Bearing Squat* at 30p (r=-.44, p=.021); *Sit-to-Stand* rise symmetry (r=-.49, p=.010); and *Step-Up-and-Over* impact force on the uninvolved limb (r=-.41, p=.036). *Squatting* correlated to *Sit-to-Stand* rise force (r=-.44, p=.023). Finally, *Total Lysholm* score correlated to *Weight Bearing Squat* at 30p (r=0.49, p=.010); and *Step-Up-and-Over* uninvolved impact force (r=.47, p=.013). **Conclusions:** Moderate correlations exist between patient-reported and performance based measures of function among cartilage patients. These findings are greater than the relationship between the Lysholm and running and hopping performance previously reported to range from insignificant to r=.36. While our results infer concurrent validity, it must be noted that only 14-27% of the variability in self-reported function could be explained by task performance. These results demonstrate the importance of collecting both patient-reported and performance based measures to fully assess functional capacity.

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**Decreases In Fasting Ghrelin Are Associated With Resumption Of Menses In Women With Exercise Associated Menstrual Disturbances**

Williams NI, Reed JL, Corr M, Kramer LC, De Souza MJ: Department of Kinesiology, Women's Health and Exercise Laboratories, Pennsylvania State University, University Park, PA

**Context:** Ghrelin, a growth hormone releasing peptide primarily secreted from the stomach, has been suggested to be a primary metabolic signal for hunger, food intake, metabolism, and energy balance. In exercising women who display menstrual disturbances, a casual role for chronic energy deficiency has been established. We have previously shown ghrelin to be significantly elevated in exercising amenorrheic women in comparison to exercising ovulatory women and exercising women with luteal phase defects and/or anovulatory menstrual cycles. Other evidence suggests a role for ghrelin in the modulation of reproductive function. **Objective:** To test

whether a negative change in fasting total ghrelin concentrations discriminates between women with exercise associated menstrual disturbances (EAMD) who resume menses vs. those who do not resume menses in response to an intervention designed to increase caloric intake but not change exercise habits. **Design:** Randomized clinical trial. **Setting:** Controlled laboratory setting. **Participants:** Subjects were exercising women aged 23.8±2.8 yrs, weighing 56.6±8.1 kg, who reported 324±290 days of amenorrhea prior to commencing the intervention. **Intervention:** After baseline procedures, participants were randomized to either an EAMD control (n=21) or EAMD + calories (n=19) intervention group. The EAMD + calories group was prescribed a 20-30% increase in caloric intake above baseline energy needs. Preliminary results were analyzed for 10 subjects in the EAMD+ calories group, comparing fasting ghrelin concentrations in 6 subjects who resumed menses vs. 4 subjects who did not resume menses over 6 months of the intervention. **Main Outcome Measures:** Fasting blood was obtained during the baseline and after 6 months and analyzed for fasting total ghrelin (Linco Research, St. Charles, MI). Body composition measures including body weight (kg), fat mass (kg), fat free mass (kg), and percent body fat were obtained at each time point using DXA. **Results:** Mean baseline ghrelin concentration in the EAMD + calories subjects who resumed menses was elevated in comparison to the subjects who did not resume menses (1384±306 vs 940±60 pg/ml, p=0.023, respectively). Independent t-tests were performed to test for differences in the change scores from baseline to 6 months in these two groups. Ghrelin declined significantly in the EAMD + calories subjects who resumed menses vs those who did not (Δ-237±88 vs Δ318±183 pg/ml, p=0.016, respectively). In those who resumed menses, mean baseline vs 6 month ghrelin concentration was 1384±306 vs 1147±171 pg/ml ($p<0.05$). No significant changes in weight, fat mass, fat free mass or percent body fat were observed between those subjects who resumed menses and those who did not. **Conclusions:** Fasting total ghrelin concentrations decreased in response to an increase in caloric intake in women with EAMD who resumed menses. These preliminary findings introduce ghrelin as a potential metabolic signal for reproductive recovery in women with EAMD. Funded by the NATA Foundation General Grant Program.

## Free Communications, Poster Presentations: Case Reports: Lower Extremity

Wednesday, June 23, 2010, 1:00PM-5:00PM, Grand Hall, authors present 4:00PM-5:00PM

### Distal Hallux Pain In An Alpine Ski Racer

Blair DF, Kiser HK, Pauly CE, Pauly SA, Tonge AM, Schoeder SA: Wenatchee High School, Wenatchee, WA

**Background:** The subject is a 16 y/o female alpine ski racer. She suffered a case of "frostbite" on her right hallux in January 2007 as a result of snug fitting ski boots. This caused an open wound on the distal aspect of her great toe. A doctor examined the wound, which eventually healed after the season concluded in April. In winter of 2008, she tried new boots with multiple modifications to stretch the toe box, but continued to have minor cases of "frostbite." The second major episode occurred in February 2009. Her distal hallux turned purple with a blood-blister under the nail, slight edema, sensitivity, and dark red drainage from the wound. She also discovered a "significant lack of tissue" under the nail, but competed despite this condition. **Differential Diagnosis:** Ewing sarcoma, osteosarcoma, ostoemylelitis, gout, neuroblastoma, pressure osteonecrosis. **Treatment**: The athlete visited her pediatrician who treated the ulcerations and referred her to a podiatrist. The podiatrist's examination included measuring skin temperature (89° F involved side, 80° F contralateral). X-rays revealed erosive changes of the distal medial aspect of the right hallux and a cystic erosion of the distal lateral aspect of the hallux. MRI showed abnormal bone marrow edema and a mild amount of enhancement within the distal phalanx of the hallux. No cultures were obtained due to lack of discharge. Inflammatory markers were normal. Based on the above findings, physicians made a tentative working diagnosis of osteomylelitis. Surgery was performed on 3/19/2009. Dark, necrotic tissue was excised from the distal medial plantar aspect of the hallux. The bone was notably soft in this area. A partial excision of the distal tuft of the right hallux was performed. A bone culture was taken and revealed Streptococcus viridans and Coagulase-negative staphylococcus, confirming the osteomylelitis diagnosis. She was started on Zosyn IV immediately following the surgery. The incision was left open to allow for drainage and debridement, and she returned to the OR for closure of the incision three days later (3/22/2009). Upon release, she started a six-week course of clindamycin. The athlete progressed from non-weight bearing to a walking boot within the first week. She underwent rehabilitation to improve the function of her toe and was able to resume pain-free activities soon after. Her follow-up rehabilitation includes functional multi-planar core strengthening workouts with an ATC twice a week. **Uniqueness:** The question of why there was a two-year gap between the initial "frostbite" and the surgery/diagnosis is puzzling. It is still not clear if the initial ulceration was caused by cold injury alone or in conjunction with constant pressure to the area. The open lesion was an avenue for the bacteria to enter the tissue and infect the bone. We also question the point at which the bacteria actually entered the area. Did it "wall" itself off and lie semi-dormant for nearly two years, or was the first lesion solely cold/pressure related and the infection entered through the February 2009 lesion weeks before the diagnosis? Although final lab cultures definitively diagnosed the osteomyelitis, some of the soft tissue and bony pathology may be the result of pressure necrosis. **Conclusions:** The athlete returned to full activity and ski racing in June 2009. She noticed a slight deficit in balance, has some difficulty transferring power through her great toe, and still has slight pain on the distal tip of the toe, especially with direct pressure. She is presently rated in the top three female ski racers in her age group in the Pacific Northwest and top 20 nationally. She actively trains six days per week and continues to race with high aspirations.

### Bipartite Sesamoid Fracture With A Partial Sesamoidectomy In A Female Collegiate Volleyball Player: A Case Report

Smith N, Berry DC, Weir N, Jensen R: Weber State University, Ogden, UT

**Background:** We present the case of a collegiate female volleyball player who suffered a fracture to the medial hallux sesamoid that eventually resulted in a sesamoidectomy. A 19-year-old female collegiate volleyball player (body mass = 62.5 kg, height = 176.5 cm) reported to the athletic trainer complaining of right, distal metatarsal pain after lunging for a volleyball, hyperextending her right great toe while simultaneously suffering a blunt trauma to the metatarsophalangeal (MTP) area. Diagnosed with a MTP joint sprain, the athletic trainer attempted to limit MTP hyperextension and padded the sesamoids. After 3 months of persistent plantar MTP

joint and sesamoid pain, the athlete was referred to a podiatrist. She presented with right plantar MTP joint pain and localized swelling to the sesamoids. Radiographs were unremarkable and demonstrated no bony trauma to the MTP joint or sesamoids. The podiatrist diagnosed the athlete with sesamoiditis and recommended continued conservative care. **Differential Diagnosis:** MTP joint sprain, sesamoiditis, bursitis, and hallux flexor strain. **Treatment:** Conservative care began with a 1cc injection of Kenalog® and a shoe insert with padding to un-weight the sesamoids. The injection and one month of rest-modified activity assisted in managing the pain; however, the athlete suffered a grade 2 lateral ankle sprain one week prior to her follow-up visit with the podiatrist. Follow-up radiographs of the foot and ankle at 4 months revealed an obvious bipartite sesamoid, separated into dorsal and plantar halves. Conservative care was continued for three more months with the shoe insert to un-weight the sesamoid which was worn continually. The athlete also received a monthly Kenalog® injection. After an additional month of rest without an injection, the podiatrist recommended removal of the bipartite sesamoid. The athlete underwent a partial sesamoidectomy. Once the medial sesamoid was exposed it was noted to be in dorsal and plantar halves with an extremely sharp plantar fragment exposed inferiorly which the athlete was ambulating on. The sesamoid was planed and approximately one-half of the inferior sesamoid was removed. After the sesamoidectomy the athlete was placed in a non-weight bearing splint for 7 days followed by a cast for 10 days. The athlete successfully returned to full activity and competition 6 months after the surgery. **Uniqueness:** Sesamoid fractures are uncommon in collegiate volleyball players. Sesamoid fractures normally occur due to forced hyperextension of the hallux and MTP joint. Athletes such as baseball catchers and ballet dancers are at greatest risk for these injuries due to the stress placed on the toe during activity. Usually conservative care resolves the issue. When conservative care fails, which is rarely, surgical intervention is required to fixate the fracture, or remove the sesamoid altogether. **Conclusions:** Athletic trainers need to remain aware of the signs and symptoms of sesamoid injuries, treatment strategies, and the most current evidence-based medicine. However, like fractures to the navicular, fractures of the sesamoids can take months to demonstrate radiographic evidence of trauma. It has been noted by researchers that sesamoid injuries are on the rise and becoming more prevalent in the athletic community as we begin to understand more about the importance of this structure. In fact, sesamoid fractures may account for up to 3% of all stress fractures currently reported. The mechanism of injury leading to acute sesamoid fractures can include: (1) fall from a height, (2) crush injury to the forefoot, or (3) sudden loading of the first MTP joint. Sometimes, forced great-toe dorsiflexion and abduction can result in a fracture by an indirect mechanism. Athletes suffering from a sesamoid fracture generally respond to conservative care, however, as in this case, surgical intervention may be necessary.

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### Cam Impingement Of The Hip In Collegiate Athlete

Tolson J, Ritchie S, Buckley T: Glenville State College, Glenville, WV, and Georgia Southern University, Statesboro, GA

**Background:** An 18 year old male varsity soccer player had a history of left snapping hip syndrome of the iliopsoas muscle. The initial injury was caused by an opponent's knee to the left medial aspect of the thigh resulting in a "popping" feeling of the left hip during club soccer in January. The athlete was treated for 5 months by family physician before seeking a second opinion and was subsequently diagnosed with internal snapping hip syndrome. Diagnostic testing confirmed the diagnosis and the athlete underwent surgery to release the iliopsoas tendon in June. The athlete was cleared to return to participation in August despite a 4/5 hip flexor weakness. During preseason, the athlete irritated the hip and was held from activity and performed rehabilitation throughout September until he was cleared to return. Six days after returning, the athlete reinjured the hip when landing and externally rotating his left hip after heading. The athlete reported feeling a "pop" in his left hip causing it to "give out." Following a physician diagnosis of a mild to moderate muscle strain, the athlete attempted rehabilitation as tolerated for 4 weeks. However, the athlete did not improve and complained of a "popping", feeling of subluxation, increased pain during prolong sitting, and deep groin pain. Athlete digressed with, decreased hip flexion, decreased internal rotation, and had a positive impingement test. The athlete sought a second opinion in January and had x-ray, MRI, MRA, and CT scan completed. Doctor also found a positive impingement test and positive figure-4 test. Athlete was diagnosed with CAM impingement and labral tear of the left hip. **Differential Diagnosis:** internal snapping hip syndrome, iliopsoas strain, labral tear, CAM impingement **Treatment:** Over a 12 month period, the athlete was treated by three physicians and underwent x-rays, MRI with and without contrast, and CT scans to try and diagnose his hip injury. Rehabilitation had focused on increasing range of motion and strength following the initial surgery to correct the snapping hip syndrome. After the second injury to his hip, the athlete had a femoroplasty and labral debridement completed to correct the CAM impingement. Rehabilitation included interferential current, pulsed ultrasound, and hip protocol from the doctor. Athlete was able to return to full play. **Uniqueness:** A CAM impingement is commonly found in known hip diseases such as femoral neck fractures, Slipped Capital Femoral Epiphysis, Legg-Calve-Perthes disease, and Malunion Femoral Neck Fractures; however the athlete had none of these conditions. CAM impingement is a rarity for a college athlete, but common in the younger and older populations. CAM impingement is initially diagnosed as a unilateral issue, but later found as a bilateral problem. CAM impingement can take as long as 3-6 month on average to diagnose. To date, there are no long term studies on rehabilitation of an athlete and the return to play success of athletes after femoroplasty. **Conclusions:** CAM impingements are difficult to diagnose due to the presentation of signs and symptoms and its rarity in athletics. CAM impingements are typically overlooked in athletics because many physicians are not familiar with it in this population and because it is commonly associated with hip diseases. Key signs and symptoms are increased pain with prolonged sitting, deep groin pain, and positive impingement test.

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### Anterior Compartment Syndrome In A Collegiate Male Nordic Skier: A Case Report

Woods KM, Nakagama NK, Yochem EM, Hicks-Little CA: University of Utah, Salt Lake City, UT

**Background**: We present a case of anterior compartment syndrome in an NCAA Division 1 Nordic skier. The report involves a healthy 19 year old Caucasian male in his first year as a Ski team member but had been previously racing competitively for 10 years. The athlete initially complained of burning/cramping bilateral anterior shin pain occurring 10-15 minutes into a classic roller-skiing uphill timed trial. This was the first incidence of pain while skiing using the classic technique. The athlete stated that the pain first began during the previous ski-racing season and that he would occasionally drag his ski tips due to weakness and inability to dorsiflex his ankle caused by the pain. The athlete stated that for the past year he has had bilateral anterior shin pain while practicing the skating technique. During this period, the athlete treated his pain with off-the-shelf shoe inserts,

massage therapy and one month of rest with no change or cessation of pain symptoms. Upon evaluation by an ATC, the athlete had no visible edema, ecchymosis or deformity and active and passive ranges of motion did not reproduce symptoms. **Differential Diagnosis**: Medial Tibial Stress Syndrome (MTSS), fibular and tibial stress fractures, deep vein thrombosis, fascial defects, nerve entrapment syndromes, radiculopathy, and vascular claudication. **Treatment**: The athlete was seen by the team physician for clinical evaluation and inter-compartmental pressure (ICP) testing. ICP testing using a Stryker monitor and an 18-gauge needle with side port was placed in the compartments of the lower right leg. Pre-exertion pressures were: Lateral 15 mmHg, Anterior 42 mmHg, Deep Posterior 12 mmHg, and Superficial Posterior 11 mmHg. The athlete was then instructed to roller-ski until symptoms were reproduced using the skating technique; pain and symptoms reoccurred within 10 minutes. Post-exertion pressures were: Lateral 16 mmHg, Anterior 81 mmHg, Deep Posterior 15 mmHg, and Superficial Posterior 12 mmHG. Normal intercompartmental pressures range between 10 and 15 mmHg. Due to the athlete's abnormal anterior compartmental pressures, he was diagnosed with compartment syndrome and referred to the team orthopedic surgeon. The orthopedic surgeon agreed with the team physician's diagnosis and recommended bilateral anterior compartment releases. Due to the nature of Nordic skate skiing, it was also recommended that the lateral compartment be released bilaterally as well. Bilateral anterior compartment and lateral compartment fasciotomies were performed with no complications. Sutures were removed 6 days post-surgery and full range of motion in both knees and ankles was maintained. The team orthopedic surgeon recommended that the athlete progress rehabilitation slowly based on pain, moving from light indoor training to outdoor activities and eventually skiing activity. In addition to ankle range of motion, strengthening and proprioceptive training, the athlete participated regularly in bilateral Game-Ready modality treatments. To date, the athlete has roller-skied using both the classic and skating techniques with no pain and minimal swelling post-exertion. **Uniqueness**: This case is unique because the incidence of compartment syndrome in the Nordic skiing population is greatly underappreciated. To our knowledge, this is the first case reporting a Nordic skier with confirmed compartment syndrome. **Conclusions**: Compartment syndrome is a painful and debilitating injury as it pertains to sports activity. To date, the only reported successful treatment for the syndrome is complete cessation of activity or fasciotomy surgery. The purpose of this case is to raise awareness regarding compartment syndrome within the Nordic skiing community. Due to its high incidence, there is need for future research regarding the prevalence of compartment syndrome in Nordic skiing to determine whether or not less invasive or alternative methods may be beneficial in dealing with compartment syndrome.

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**Knee Pain In A Division I Female Volleyball Player**

Lopez JE, Pallone AS, Straub SJ, Nissen CW: Quinnipiac University, Hamden, CT, and Elite Sports Medicine Connecticut Children's Medical Center, Farmington, CT

**Background:** In 2008, an 18 year old freshman, female Division I collegiate volleyball player began to complain of an insidious onset of left knee pain with deep squats, jumping, and sprinting after a pre-season practice. There was a slight presence of edema and global muscle weakness was noted with her left lower extremity when compared contralaterally. The athlete had a long history of left knee injuries including: three partial medial menisectomies, a lateral meniscal repair, two ACL reconstructions, and chondroplasties of the patella, medial femoral condyle, medial tibial plateau, and lateral femoral condyle. Initial conservative treatment consisted of limiting activities, NSAIDS, rehabilitation exercises, McConnell's patellafemoral taping, and the use of local measures for pain control. The pain progressively increased, and the athlete began complaining of pain and "popping and clicking" with activities of daily living. The athlete was then seen by an orthopedist who prescribed Naprosyn, suggested the use of a patella-femoral brace, and discussed the possibility of terminating her playing career. Despite adhering to all conservative treatments, the knee pain increased. At the end of her season the athlete pursued a second opinion. On exam, the new orthopedist noted a positive Lachman's and after reviewing an x-ray was concerned with the extent of any chondral defects and meniscal tears. **Differential Diagnosis:** ACL tear, increased severity of chondromalacia, osteo-arthritic changes, meniscal tear. **Treatment:** The athlete was diagnosed with an ACL tear, Grade II chondromalacia of the trochlear groove, and a medial meniscal tear. In January of 2009, the athlete underwent left knee ACL reconstructive surgery, chondroplasty of the trochlear groove, and a partial medial menisectomy. Rehabilitation began following surgery per physician's protocol. The athlete was progressing normally until 4 months after her surgery, when her rehabilitation reached a plateau due to her knee pain. The athlete returned to the orthopedist and decided to undergo a left knee Anterior Medialization (AMZ) and Autologous Chondrocyte Implantation (ACI) in July of 2009, to address her knee pain. At this time the athlete is steadily progressing through her rehabilitation with no symptoms of knee pain or signs of complication although she will not be participating in the 2009 season. **Uniqueness:** The ACI procedure is relatively new to the medical field. The long term outcomes are not fully known. Since the ACI is a new procedure there are not many reported cases of ACI and AMZ being performed concurrently. The initial 6-8 weeks of the rehabilitation process for the ACI procedure is drastically different than AMZ procedure. Thus the incorporation of both of these rehabilitations is uncommon. **Conclusion:** The ACI procedure consists of harvesting a small amount of hyaline cartilage from a nonweightbearing portion of the lateral femoral condyle, growing it in a lab and re-injecting it into the chondral defect of the subject, to repair the lesion. The AMZ procedure consists of surgically advancing the tibial tubercle anteromedially, in order to decrease the amount of contact pressure within the patellofemoral joint. The ACI has been performed for about 12 years; in 2004 it was reported that roughly 10,000 procedures have been performed worldwide. The initial weeks of rehabilitation for the ACI procedure includes continuous passive range of motion, while the AMZ rehabilitation deters it. Advancements in medicine have made it possible for more athletes to return to play, where as in the past they may have been discouraged from athletic participation due to the long term sequela of their injury. These procedures use different methods in treating articular cartilage defects, and have been noted as secondary procedures, when the initial surgically treatment fails.

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**Medial Foot Pain In A Division I Collegiate Softball Player**

Brunelle ME, White T, Straub SJ: Quinnipiac University, Hamden, CT

**Background:** An 18 year old female collegiate softball player presented with an antalgic gait and complained of intermittent soreness and pain along her medial instep, when walking and running. The athlete had a history of anterior tibialis strain/ calcaneonavicular ligament sprain 2 months prior. Upon current evaluation, tenderness to palpation was revealed over the navicular tuberosity and along the distal posterior tibialis tendon from the insertion at the navicular to the medial

malleolus. Observation revealed inflammation over the navicular tuberosity, and through palpation, an abnormality of the navicular bone was noted. Range of motion was full but active and passive motions of combined plantarflexion with inversion and combined dorsiflexion with inversion elicited pain of 5/10. The athlete was removed from play and referred to the team physician. **Differential Diagnosis:** Posterior tibialis tendonitis, Posterior tibialis strain, navicular fracture, accessory navicular. **Treatment:** X-ray imaging confirmed the presence of an accessory navicular, type II. The athlete was directed to ambulate in a walking boot for four weeks, take a prescription anti-inflammatory and a cortisone injection was recommended. The athlete and her family declined the cortisone injection. Rehabilitation and all weight bearing athletic activities were discontinued. Treatment was altered to include thermal ultrasound treatment once daily to decrease inflammation in the tendon and ice treatments three times daily. Following one week of treatment, the athlete reported no pain. US treatments were discontinued and the athlete was treated symptomatically. Prior to her follow up visit, the coaching staff removed the athlete from the roster and reassigned her to the position of team manager for reasons unrelated to her injury. The athlete remained in the walking boot and was treated for intermittent pain throughout the next three weeks. Four weeks after the initial assessment, the athlete returned to the physician and received options to either continue symptomatic treatment or to pursue surgery. Three days after the visit, the athlete discontinued activities with the softball team and communication with the athletic training staff. In a recent discussion, the athlete reported pain of 3/10 when walking long distances and progression to exercising on the elliptical machine. The athlete does not plan on pursuing any surgical treatment. **Uniqueness:** Collectively, the three types of accessory navicular have an incidence rate of between 4-21%, but only type II and III typically present symptomatically. The incidence rate of type II and type III have been reported at 3.1 and 4.6% respectively. **Conclusion:** Often, effective treatment for accessory navicular includes treatments to decrease inflammation and fitting of orthotic devices. This athlete did not continue with treatment long enough that orthotic intervention was attempted. A correlation reported between increased BMI and increased foot pain would also suggest that decreasing an athlete's BMI through diet and exercise may also decrease symptoms.

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**Anterior Compartment Syndrome And Tibial Stress Fracture In A Lacrosse Goalie**

Park MN, Simons BL, Gockley LS, Loughry RM, Siple BJ: Slippery Rock University of Pennsylvania, Slippery Rock, PA

**Background:** The purpose of this case study is to examine anterior compartment syndrome with an accompanying tibial stress fracture in a twenty-one year old collegiate female lacrosse goalie. No previous history of lower leg pain was reported prior to injury. The mechanism of injury in this case was direct, repetitive blows to the anterior aspect of her left tibia with a lacrosse ball. Despite the certified athletic trainer's repeated requests, the goalie refused to wear shin protection during lacrosse activities. She suffered significant contusions to both upper and lower legs; however, only her left lower leg became symptomatic. Initial trauma began during off-season training approximately five months prior to the start of the competitive spring lacrosse season. Midway through the season, the athlete reported increasing pain along the anterior portion of the left lower leg after practices and games. The pain was dull with moments of radiating or sharp pain. Further evaluation revealed extreme point tenderness over the middle-third of the antero-medial tibia. Two weeks later, the athlete began presenting with edema in the lower leg and marked weakness and pain with AROM and RROM dorsiflexion. The athlete finally complied with previous requests of wearing protective shin guards. Despite the protective equipment, blows to the tibia continued to cause edema. The athlete was diagnosed with anterior compartment syndrome and a tibial stress fracture following a compartment pressure test, bone scan and magnetic resonance imaging. The athlete was disqualified from lacrosse participation in order to allow appropriate healing of the stress fracture which was possibly causing the signs and symptoms of increased pressure in the anterior compartment. During the follow-up evaluation, the athlete was cleared for low impact activities since the symptoms related to the anterior compartment syndrome had resolved. The athlete continued to participate in practice as long as pain related to the tibial stress fracture was tolerable. **Differential Diagnosis:** Deep vein thrombosis, medial tibial stress syndrome and strain of the tibialis anterior. **Treatment:** With potential causes of increased pressure due to the tibial stress fracture in the anterior compartment region, the physician recommended delaying a fasciotomy until all signs and symptoms of the stress fracture were resolved. The athlete continued to participate in rehabilitation exercises and low impact activities as tolerated. She consistently wore shin protection with a foam donut pad over the most painful site on the tibia. **Uniqueness:** The most common cause of anterior compartment syndrome is chronic overuse, but this case is unique because the mechanism of injury was caused by frequent, direct impact from lacrosse balls to the lower leg over a repeated period of time. **Conclusions:** It is important for athletes and coaches to comply with not only the treatment and rehabilitation recommendations of certified athletic trainers, but the injury prevention recommendations that are given. Although anterior compartment syndrome and stress fractures in the lower extremity occur frequently as a result of chronic overuse they can occur alone or simultaneously as a result of repetitive acute trauma.

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**Athletic Training Services Associated With Appropriate Medical Care In South Carolina High School Athletics**


Wham GS, Saunders RP, Mensch JM, Potts JW: University of South Carolina, Columbia, SC, and Pelion High School, Pelion, SC


**Context:** Employing athletic trainers(AT) in secondary schools has long been recommended as key to improving medical care for the secondary school-aged athlete. Recent research suggests South Carolina(SC) schools with AT services better meet the standards established in the Appropriate Medical Care for Secondary School-aged Athletes(AMCSSAA) Consensus Statement/ Monograph; however, no research has examined the relationship between AT services and individual AMCSSAA Consensus Statement recommendations. **Objective:** To examine the relationship between provision of AT services and each AMCSSAA Consensus Statement recommendation. **Design:** Cross-sectional study. **Setting:** Mailed/emailed survey. **Participants:** 166 SC high schools. **Intervention(s):** AMCSSAA Monograph recommendations for each point of the AMCSSAA Consensus Statement were identified, summarized, rephrased as policies or practices, and included as items on the 132-item Appropriate Medical Care Assessment Tool(AMCAT). Also included were items assessing potential influences on medical care. After pilot-testing, data were collected via a systematic, modified-Dillman approach with 63%(166/263) of schools responding. Test-retest reliability was strong (r=.89). SPSS was used to calculate descriptive statistics and multiple comparison tests. Presence of AT services served as independent variable. **Main Outcome Measure(s):** Each AMCAT item corresponded to a specific AMCSSAA recommendation category. Items were scored 3, 2, 1, or 0 on a 4-point scale. Points accumulated from items in each recommendation category were summed then divided by the total number of points possible in that category yielding ten recommendation category scores ranging between 0 and 1. Higher scores indicated more favorable provision of medical care in that AMCSSAA recommendation category. Each AMCSSAA recommendation category score served as a dependent variable providing a quantitative measure for the proficiency with which the recommendation was met. **Results:** Significant differences in recommendation category scores existed between schools with AT services and those without AT services for the following AMCSSAA recommend-ations: Readiness to Participate [AT.75(.14) and no AT.68(.18), F=6.28,p<.013], Safe/Appropriate Facilities [AT.77(.14) and no AT.70(.16), F=5.46,p<.021], Emergency Planning [AT .73(.19) and no AT.50(.19), F=40.69,p<.001], Injury Evaluation [.52(.16) and no AT .26(.18), F=72.28,p<.001], Injury Rehabilitation [AT .36(.15) and no AT .14(.12), F=68.75,p<.001], Psychosocial Consult-ation/Referral [AT.42(.33) and no AT(.29(.24), F=5.36,p<.022], and Healthcare Administration System [AT .69(.20) and No AT .47(.22), F=31.1,p<.001]. No differences were identified for: Selection/Fit/Funtion/ Mainentance of Athletic Equipment [AT .69(.17)andnoAT.64(.21), F=3.445,p<.065], EnvironmentalProtocols [AT.70(.28)and no AT.72(.28), F=.121,p<.073], and Nutritional Counseling/Education [AT.52(.23) and no AT .46(.22), F=2.20,p<.14]. **Conclusions:** In SC high school athletics, schools with AT services reported providing higher levels of medical care in determining readiness to participate, providing safe/appropriate facilities, emergency planning, injury evaluation, injury rehabilitation, psychosocial consultation/referral, and healthcare administration. These results provide suggestive guidance for decision-makers (school administrators and legislators) and those who influence decision-makers (parents and athletes) in improving the medical care provided for interscholastic athletes.

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**Characteristics Of Interactions Between Certified Athletic Trainers And Emergency Medical Services Personnel In Secondary School And Collegiate Settings: A National Survey**


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**Context:** Anecdotal reports describe disagreements between certified athletic trainers (ATs) and emergency medical services personnel (EMS), particularly concerning management of helmet and shoulder pads during care of football head/neck injuries. Such conflict could negatively affect care of injured athletes. However, no data support these anecdotes. **Objectives:** To describe the frequency and characteristics of AT-EMS interactions and assess differences by work setting (secondary school versus college). **Design and Setting:** Cross-sectional, anonymous web-based survey (Survey-Monkey) conducted January-March, 2009. **Participants:** NATA members (Certified) in secondary school and college/university settings. All members consenting to use of emails for research purposes were surveyed. Respondents (1884/6944, rate: 27%) were 36.0±9.7 years old, 52% male and were certified in 1997±8.5. Although the response rate was low, demographics of the responding sample were not significantly different than all secondary/collegiate members. **Interventions:** A new instrument was developed using the Table of Specifications approach and cognitively tested, including face validity, using a panel of 12 football ATs and a survey methods expert. Test-retest reliability was assessed with 21 ATs taking the survey twice, 1 week apart; correlations ranged from .98-1.0. **Main Outcome Measures:** Prevalence (%, 95% confidence intervals [CI]) of ever activating EMS for any sport-related emergency and for football-specific emergency, average annual EMS activations, characteristics of activations by work setting. Chi Square tests were used to assess differences in proportions and logistic regression to calculate adjusted odds ratios (OR). **Results:** Most ATs (95.5%, CI 94.5-96.5) had activated EMS for a sport-related emergency in their career; 74.5% (CI 72.5-76.6%) average at least 1 activation annually. Most ATs with football experience had activated EMS for a football head/neck injury (78.4%, CI 76.5-80.4%). More secondary school ATs reported head/neck activations than college ATs (61% vs. 39%; $X^2(30)=15.77$, $p<0.001$). Preseason meetings with EMS were reported by 57.6% (CI 55.3-59.9) of respondents. Overall, 59% (CI 56.6-61.3%) reported a situation where they felt EMS provided inappropriate care to an athlete, 54.6% (CI 51.9-57.4%) reported inappro-priate management of football equipment by EMS, and 42% (CI 39.3-44.7%) reported at least one on-field disagreement with EMS during a football-related emergency. Secondary school ATs were 60% less likely (OR=0.40, CI 0.31-0.50; $p<0.001$) to report preseason meetings with EMS, 63% more likely to report inappropriate care (OR=1.63, CI 1.32–2.00), and 48% (OR=1.48, CI 1.15-1.90) more likely to report an on-field disagreement than collegiate ATs. ATs who reported preseason planning meetings were 27% less likely to report on-field disagreement with EMS (OR=0.73, CI 0.56–0.96; $p=0.03$) after adjusting for work setting. **Conclusions:** AT-

EMS interactions are common. From the AT perspective, there is preliminary evidence documenting on-field AT-EMS conflicts and these may be more common in the secondary school setting. Future research should investigate EMS perceptions and experiences during sport-related emergencies.

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**Collegiate Athletes Utilize Athletic Trainer's In Mental Preparation**

Donohoe K, Massie J, Vealey R: Miami University, Oxford, OH

**Context:** Psychosocial intervention and referral (PSIR) has expanded to incorporate the development of mental skills such as confidence and motivation. **Objective:** The purpose of this study is to determine collegiate athletes' perceptions of the role of ATCs in mental preparation. **Design:** This study has been informed by phenomenology to discover athlete's shared experiences with athletic trainers. Individual interviews were utilized to allow individuals to truly share their personal experiences. Focus group interviews were utilized to allow interaction between participants to determine shared experiences. **Setting:** Individual and focus group interviews were conducted on the participants' campuses in conference rooms. **Patients or Other Participants:** Coaches or advisors of collegiate athletes from NCAA Division I and Division III schools were contacted to notify athletes by word of mouth or email and those interested signed up to participate. Twenty collegiate athletes were interviewed (8 low ATC interaction sports, 12 high ATC interaction sports, 4 females, 16 males ranging in age from 17 to 22 years). The total number of participants selected for this study was guided by theory saturation. **Data Collection and Analysis:** Focus group interviews were conducted in groups ranging from four to seven participants, or single-participant interviews. Interviews were recorded and transcribed verbatim with the help of transcription services. Notes were taken during the process by the moderator and a peer. A five step process was used to analyze the data: identify big ideas, unitize the data, categorize the data, negotiate relationships, and identify themes. Trustworthiness was ensured by comparing moderator's and peers' notes as well as review from a panel of experts. **Results:** A common theme from athletes participating in sports with higher interactions with ATCs is these athletes tend to have a closer relationship with their ATC, which leads the athletes to depend on the ATC more for both physical and mental preparation for competition. Athletes feeling that their ATC goes above and beyond their perceived job description are more likely to believe the ATC has an effect on their mental preparation and also feel they don't need to worry about their injuries because the ATC is worrying for them. **Conclusions:** Athletes that see their ATC before competition are more confident that they are ready to compete. They also feel they receive moral support from their ATC, relating their ATC to a family member. This demonstrates the role of athletic trainers in mental preparation, as part of PSIR. PSIR goes beyond referring athletes to proper clinicians; it involves developing mental skills in athletes, which needs to be demonstrated to ATS' to strengthen the future of clinical practice.

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**Can You Improve The Quality Of CPR Through Feedback-Enabled Simulation Manikins And Performance Debriefing?**

Del Rossi G: University of South Florida, Tampa, FL

**Context:** The chance for a positive outcome drops considerably without prompt and appropriate care of the cardiac arrest victim. Conversely, the immediate delivery of *high-quality* CPR has been reported to increase survival rate by two- to three-fold because it assures that good coronary and cerebral perfusion pressures are attained. **Objective:** To determine if CPR skills can be enhanced by incorporating performance data obtained from a CPR simulation manikin into a detailed debriefing session in which improvement strategies are discussed. **Design:** A prospective interventional trial in which each test subject served as his or her own control. **Setting:** This study was performed in a controlled field setting (football practice facility). **Participants:** Fourteen certified athletic trainers (age = 30.2 ±7.1 years; length of time certified as an athletic trainer = 5.9 ±6.2 years) holding current CPR/AED Professional Rescuer certification. **Inter-ventions:** Each participant was required to perform 6 minutes of single-rescuer CPR on a simulation manikin in order to obtain baseline performance data which would serve as the focus of discussion during debriefing sessions. The debriefing session (independent variable) was held immediately following the acquisition of baseline measurements and lasted fifteen to twenty minutes. During the debriefing meeting, subjects were provided descriptive and visual feedback of their performance and discussed how their performance compared to the American Heart Association 2005 Guidelines for Cardiopulmonary Resuscitation. After discussing ways to improve performance, the debriefing session was terminated. Follow-up testing took place 6 months following the initial test. Paired t-tests were calculated to analyze pre- and post-debriefing performance data. **Main Outcome Measures:** Dependent variables were number of ventilations with adequate volume; number of compressions with adequate depth; number of compressions with incorrect hand placement; number of compressions that did not allow for full chest recoil; total hands-off time (i.e., time spent not delivering compressions). **Results:** Although the number of appropriate ventilations (pre=7.6 ± 7.5; post=13.1 ±11.9; p=0.081) and the number of compressions with incorrect hand placement (pre=46.6 ±78.1; post=22.4 ± 79.1; p=0.177) improved after debriefing, neither of these changes were statistically significant. Statistical analysis revealed that subjects only made significant improvements in reducing total hands off time (pre=170.8 sec ± 27.2sec; post=159.9 sec ± 18.6 sec; p=0.035). The quality of all other skills (number of compressions with appropriate depth; number of compressions with full chest recoil) actually declined after 6 months. **Conclusions:** Some CPR skills can be improved upon using a simulation manikin and performance debriefing. More research is needed to fully ascertain the extent to which CPR delivery can be enhanced using simulation training and debriefing techniques.

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**A Temporal Analysis Of Academic Degree Transitions In Five Peer Healthcare Professions**

Yakuboff MK, Sauers EL, Parsons JT: Post-Professional Athletic Training Program, A.T. Still University, Mesa, AZ

**Context:** Most healthcare professions have undergone academic degree transitions in their education standards that impact the minimum degree requirements for professional practice. Athletic training educators are debating a similar transition; however, limited data are available from which to analyze this phenomenon. **Objective:** To analyze academic degree transition timelines for five peer health professions. **Design:** A descriptive, exploratory study. **Setting:** Content analysis of healthcare professions. **Patients or Other Participants:** The following professions were investigated: pharmacy (Pharm), audiology (Au), occupational therapy (OT), physical therapy (PT), and physician assistants (PA). Academic degree transition timelines were created from temporal variables at the bachelor's, master's, and doctoral degree levels. **Data Collection and Analysis:** Data were obtained from the following sources: accreditation standards; miscellaneous professional and organizational documents; and bibliographic databases (OVID, PubMed, CINAHL, ERIC, and Proquest). An academic degree transition timeline was constructed for

each profession that included the date of degree emergence, adoption, and mandate at the bachelor's, master's, and doctoral degree levels. Subsequently, descriptive data (mean±SD years) were calculated for all professions to characterize the following degree transition intervals: adoption interval (adoption date – emergence date), mandate interval (mandate date – adoption date) and transition interval (mandate date – emergence date). **Results:** A wide spectrum of academic degree transitions was observed, ranging from the first mandated bachelor's degree for a health profession in 1932 (Pharm) to the first mandated doctoral degree in 2003 (Pharm). Only two of the five professions (40%; Pharm, OT) ever formally mandated the bachelor's degree (adoption interval = 25.6±17.6 yrs; mandate interval = 4.0±0 yrs; transition interval = 33.5±9.2 yrs). Three of the five professions (60%; Au, OT, PT) have formally mandated the master's degree (adoption interval = 47.5±14.8 yrs; mandate interval = 2±0 yrs; transition interval = 39.7±20.0 yrs). Only two of the five professions (40%; Pharm, Au) have formally mandated the doctoral degree (adoption interval = 18.8±18.9 yrs; mandate interval = 3.0±4.2 yrs; transition interval = 32.0±29.7 yrs). Despite the lack of a formal mandate, currently 5/5 (100%) of the professions studied here offer entry into the profession at the master's level and 4/5 (80%) offer entry into the profession at the doctoral level. **Conclusions:** These five healthcare professions have a wide range of degree adoption, mandate, and transition intervals and significant variability in the minimum degree required to practice. Interestingly, it appears that as institutions begin to offer higher academic degrees for a given profession (ie, transition from master's to doctoral degree), accreditation bodies often follow with subsequent degree elevation mandates. These data are of interest for administrators and educators currently evaluating the appropriate minimum academic degree level for the athletic training profession.

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**Assessing Strategies To Manage Work And Life Balance Of Certified Athletic Trainers In The Division I Clinical Setting**

Mazerolle SM, Pitney WA, Casa DJ, Pagnotta KD: University of Connecticut, Storrs, CT, and Northern Illinois University, DeKalb, IL

**Context**: Certified Athletic Trainers (ATs) working at the Division I level are experiencing challenges balancing their professional and personal lives. Organizational factors such as work schedules, work overload, and lack of control over schedules have contributed to this conflict. Little, however, is known about the strategies ATs use to help promote a balance between their personal and professional lives. **Objective**: To discuss the strategies utilized by ATs employed in the National Collegiate Athletic Association (NCAA) Division I setting to establish a balance between their personal and professional lives. **Design**: A basic qualitative design using inductive content analysis **Setting**: ATs employed at Division I schools from 5 National Athletic Trainers' Association districts. **Patients or Other Participants**: A total of 28 (15 females and 13 males) aged 35 ± 9 participated in the study. ATs averaged 12 years (3-28 years) of full-time athletic training experience, 7 were Head Athletic Trainers (HATs) and 21 were assistant athletic trainers (AATs). 17 were married and 13 of the participants had children. **Data Collection and Analysis**: In-depth, electronic interviews followed by phone interviews. Data were analyzed using an inductive content analysis. A peer review, member checking, and data source triangulation were conducted to establish trustworthiness of the data. **Results**: Three first-order themes emerged from the analysis. The initial theme, antecedents of work family conflict, identified that the demands of the profession, flexibility of work schedules, and staffing patterns contributed to work-life conflict for this group of ATs. The other two emergent first-order themes, professional factors and personal factors, describe the components of a balanced life-style. The second-order theme constructing the professional factors included both organizational policies and individual strategies, while the second-order theme of personal factors involved the separation of work and life and supportive personal network. **Conclusions**: Long work hours, lack of control over work schedules, and unbalanced sport to AT ratios can facilitate conflicts, however as demonstrated by the results of this study there are several organizational and personal strategies that are effective in creating a balanced lifestyle. Professionally, ATs are encouraged to set boundaries by establishing treatment times, saying no to additional work responsibilities, capitalizing on teamwork with co-workers, and prioritizing work and personal responsibilities each day. Personally, the participants found a balance by relying on a strong social support network, particularly those who demonstrated an understanding of the ATs demanding work schedule. Finally, many participants found a balance by creating a separation between work related issues and time spent doing personal obligations.

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**Multiple Factors Influence Students' Attitudes Toward Pursuing Graduate Study**

Allbaugh D, Smith-Goodwin E, Tecklenburg L: Wilmington College, Wilmington, OH

**Context:** Knowing the current trends influencing undergraduate athletic training students' graduate school selection is important. It can give undergraduate advisors a better understanding of how to guide students toward graduate school. It can also give institutions insight on recruiting graduate students. **Objective:** The purpose of this study is to investigate the attitudes of undergraduate athletic training students from a mid-west Division III institution concerning factors that influence their graduate school selection. **Design:** Nonexperimental cross-sectional descriptive survey. **Setting:** Undergraduate Athletic Training Education Program. **Participants:** The target population was a convenience sample of athletic training students (N=82). The response rate was 100%. 32% (n=27) of the students were male and 67% (n=55) were female. Freshman represented 40% (n=33), sophomores 25% (n=21), juniors 20% (n=16), and seniors 15% (n=12). **Interventions:** The survey consisted of 20 questions including demographics. A Table of Specifications (ToS) established content validity; a panel of experts review established face validity. Questions addressed the influential factors for school selection (#1-10), parental influences on attending graduate school (#11, 12, 15), other external influences (#13-14), the participants' financial situation (#3-4, 14, 16-17), and demographics (#18-20). Surveys were distributed and collected in athletic training classes. Descriptive statistics (frequency counts and percentages) were calculated using SPSS 15.0. Institutional Review Board approval was obtained. **Main Outcome Measures:** A rank order from 1 to 10 was used for factors influencing graduate school selection with 1 being "most important" and 10 being "least important." The remaining questions had scale type answer selection including yes/no and nominal data choices. **Results:** The overall ranking from most important to least important were: 1)program quality, 2)accreditation, 3)cost of tuition, 4)securing some sort of assistantship, 5)location, 6)faculty/student ratio, 7)maintained facilities, 8)student life services, 9)admission requirements 10)student support services. 33% (n=27) of the participants selected program quality as the most influential factor. Although it should be noted that 42% (n= 5) of the senior class said that securing some sort of assistantship was the most influential factor. 70% (n=57) reported that pursuing graduate

education was more important than getting a job after graduation. 33% (n=4) of seniors reported $50,000-$75,000 of undergraduate debt. 67% (n=8) of seniors reported that they would only attend graduate school if they received an assistantship or some other financial aid. 47% (n=39) reported frequently discussing graduate school decisions with their parents. Little difference was found between genders regardless of grade. **Conclusion:** This study reflects the significant relationship of students securing some sort of assistantship when deciding to pursue graduate education. It also shows that students become increasing aware of the cost of education as they near graduation.

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**Athletes' Perceptions Of Athletic Trainers With Disabilities**

Sturgill E, Smith-Goodwin E, Miller K: Wilmington College, Wilmington, OH

**Context:** In an athletic training education program there are "Technical Standards" that students must meet in order to successfully complete the educational program. Some of the technical standards include: hear and understand the normal speaking voice, and demonstrate sufficient manual dexterity, strength, and stamina. No institution can exclude an "otherwise qualified" applicant or student merely because of a disability. **Objective:** The purpose of this study was to investigate DIII student athletes' (men and women soccer players) perceptions on athletic trainers with disabilities. **Design:** Nonexperimental cross-sectional descriptive survey. **Setting:** Southwestern Ohio, Division III college. **Patients or Other Participants:** The target population (N=52) was a convenience sample of soccer players: men (n=28) and women (n=24) in Southwestern Ohio (100% return rate). 54% (n=28) were male, and 46% (n=24) were female. 23% (n=12) were freshmen, 33% (n=17) were sophomores, 19% (n=10) were juniors, and 25% (n=13) were seniors. **Interventions:** The survey consisted of 13 questions including demographics. Questions addressed issues regarding an athletic trainer with a disability: degree of comfort (#1,2,6,9,11), quality of care (#3), equality of an athletic trainer without disabilities (#4,7,8,10), athletes' experience with an athletic trainer with a disability (#5), and demographics (#12-13). A Table of Specifications established content validity; a review by a panel of experts established face validity. Institutional Review Board approval was obtained. The surveys were handed out/collected during a practice. A Chi Square test with gender as the grouping variable, and a Kruskal-Wallis test with class rank as the grouping variable were tested against the dependant variables of the survey. Descriptive statistics (frequency counts and percentages) were calculated. Alpha level was set *a priori* at 0.05. **Main Outcome Measures:** A Likert type scale of 4=strongly agree, 3=agree, 2=disagree, 1=strongly disagree was used. **Results:** Class rank showed that student athletes agreed (M=3.23± .783) they would be comfortable having an athletic trainer with a disability (H= 8.278,df= 3,P= .041.) Ironically, 25% (n=13) disagreed that an institution should hire an athletic trainer with a disability. 81% (n=42) of student athletes have not had personal experience with an athletic trainer with a disability (H= 8.502,df= 3,P= .037). 90% (n=48) indicated they would "not pass judgment" on an athletic trainer with a disability. 19% (n=10) did agree that an athletic trainer with a disability would be less qualified. **Conclusion:** The majority of student athletes strongly agreed that they were comfortable having an athletic trainer with a disability. However, it seems that athletes are still discriminatory in some regards to an athletic trainer with a disability. More needs to be done in the profession for inclusion of athletic trainers with disabilities.

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# Free Communications, Poster Presentations: Prevention, Measurement, & Effects of Dehydration

Wednesday, June 23, 2010, 1:00PM-5:00PM, Grand Hall, authors present 4:00PM-5:00PM

**Hypohydration Does Not Affect The Threshold Frequency, Duration, Or Intensity Of Electrically-Induced Muscle Cramps**

Miller KC, Mack GW, Knight KL, Hopkins JT, Draper DO, Fields PJ, Hunter I: North Dakota State University, Fargo, ND, and Brigham Young University, Provo, UT

**Context:** Controversy exists regarding whether exercise-associated muscle cramps (EAMC) are caused by dehydration/electrolyte losses or neuromuscular fatigue. Proponents of the dehydration/electrolyte theory suggest that exercise-induced sweating causes a contracture of the extracellular space which results in the hyperexcitability of nerve terminals and leads to cramping. If true, cramp threshold frequency (TF), the electrical stimulation frequency at which a cramp occurs, should decrease when subjects are hypohydrated. It is also unknown if hypohydration increases the duration or intensity of electrically-induced muscle cramps. **Objectives:** We sought to minimize dominant limb neuromuscular fatigue and determine if hypohydration with concurrent electrolyte losses cause (1) a decrease in cramp TF (inferring greater susceptibility to cramping) or (2) an increase in the duration and intensity of electrically-induced cramps. **Design:** Cross-sectional, experimental design. **Setting:** Laboratory. **Patients or Other Participants:** Ten cramp prone males (age=23.5±1.0 ht=177.8±1.8 cm, mass= 73.9±2.8 kg). **Interventions:** Dominant limb flexor hallucis brevis muscle cramp TF, duration, and intensity was determined while subjects were euhydrated. Subjects cycled for 30 min bouts with only their nondominant leg (41°C and 15% relative humidity) until they lost ~3% of their body mass. Upon achieving ~3% hypohydration, cramp TF, duration, and intensity was reassessed. Subjects repeated this protocol 1 week later. **Main Outcome Measures:** (1) Cramp duration (s) was defined as the difference between the start of cramp EMG activity and the point when cramp EMG activity decreased to within 2 SD of resting EMG activity. (2) Cramp intensity (% of maximum voluntary isometric contraction [MVIC] EMG activity) was determined by normalizing the 2-s of cramp EMG immediately following conclusion of the electrical stimulation to the mean 2-s MVIC EMG activity and multiplying by 100. (3) Total sodium ($Na^+$), potassium ($K^+$), magnesium ($Mg^{+2}$), and calcium ($Ca^{+2}$) lost postexercise were calculated. (4) Plasma osmolality ($OSM_p$) was used to characterize hydration status. **Results:** Subjects were euhydrated preexercise ($OSM_p$=282.5±0.7 mOsm*$kg^{-1}$ $H_20$) and hypohydrated after ~2 h exercise ($OSM_p$= 295.1±1.1 mOsm*$kg^{-1}$ $H_20$; $F_{1,9}$=215.61, $P$<0.001). Subjects lost 3.0±0.1% of their body mass, 144.9±9.8 mmol of $Na^+$, 11.2±0.4 mmol of $K^+$, 3.3±0.3 mmol of $Mg^{+2}$, and 3.1±0.1 mmol of $Ca^{+2}$. Mild hypohydration did not affect crampTF (euhydrated =23.7±1.5Hz, hypohydrated =21.3±1.4 Hz; $F_{1,9}$=2.8, $P$=0.12), duration (euhydrated =142.7±10.4 s, hypohydrated =152.6±13.9 s; $F_{1,9}$=2.9, $P$=0.12), or intensity (euhydrated =69±6%, hypohydrated=64±6% of MVIC EMG activity

($F_{1,9}$=0.3, *P*=0.59). **Conclusions:** Mild hypohydration does not appear to predispose individuals to cramping (per cramp TF). Thus, cramps may be more associated with neuromuscular fatigue than dehydration/ electrolyte losses. Clinicians may have more success preventing EAMC by focusing on strategies which minimize peripheral fatigue rather than dehydration. Electrically-induced muscle cramps lasting >2 min can be induced without hypohydration. Having a model which induces cramps that last several minutes is beneficial for studying cramp treatments.

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**Hydration Status Of NCAA Division IA Football Players At High- Versus Low-Risk For Exertional Heat Illness During Pre-Season Practices**

Cleary MA, Hetzler RK, Wong BC, Okasaki EM, Nichols AW, Kimura IK: Department of Kinesiology and Rehabilitation Science, Human Performance Research Laboratory, University of Hawaii at Manoa, Honolulu, HI; Department of Intercollegiate Athletics, University of Hawaii at Manoa, Honolulu, HI; Department of Family Medicine & Community Health, Division of Sports Medicine, John A. Burns School of Medicine, University of Hawaii at Manoa, Honolulu, HI

**Context:** Athletes at higher risk for exertional heat illness may be less likely to maintain hydration status during pre-season practices in warm, humid environments. **Objective:** To compare hydration status in NCAA Division IA football players identified as High Risk (HR) or Low Risk (LR) for exertional heat illness during pre-season football training camp. **Design:** A two-group pre-post test repeated-measures observational study. **Setting:** This study was performed in a warm, humid sub-tropical climate during real-life collegiate football pre-season training camp consisting of 17 practices over 14 days following NCAA regulations. **Participants:** We screened 86 Division IA football players prior to pre-season camp, 25 volunteered for hydration testing and were classified as HR (*n*=12,age =20.6±1.9 years, mass=105.9±17.6 kg, height=185.1±5.6 cm, BSA=2.3±0.2 $m^2$, BMI=30.8±4.2 kg/$m^2$) and LR (*n*=13, age=20.8±1.4 years, mass=96.3±197.1 kg, height =181.6±5.6 cm, BSA=2.2±0.2 $m^2$, BMI=29.0±4.4 kg/$m^2$) with no significant differences between groups. The independent variables were: HR group classified as reporting previous history of exertional heat illness or other risk factors and LR group classified as reporting no history or other major risk factors. **Interventions:** This was an observational study with no experimental interventions. **Main Outcome Measures:** Hydration was assessed pre-and post-practice using: body mass loss (BML); urine specific gravity ($U_{sg}$) with values ≥ 1.020 indicating dehydration; and urine color ($U_{col}$) on an 8-point color scale with values ≥ 4 indicating dehydration. Environmental conditions were recorded using a wet bulb globe temperature (WBGT) monitor during the first 15 min and last 15 min of practice. **Results:** HR participants reported having previous history of exertional heat illness with 58% (=7/12) reported having heat exhaustion, 33% (*n*=4/12) having heat cramps, 0% (*n*=0/12) having a heat stroke, and 58% (*n*=7/12) were dehydrated ($U_{sg}$≥1.020 µg) during baseline testing. Compared to norms, both groups were in the 85-90$^{th}$ percentile on BSA (HR=2.3±0.2 $m^2$, LR=2.1±0.2 $m^2$, *p* =.158) and BMI (HR =30.8±4.2 kg/$m^2$, LR=29.0±4.4 kg/$m^2$, *p*=.323) but were not significantly different. Environmental conditions ranged from WBGT=24.0–31.4°C and were consistently high (WBGT= 27.2±2.0°C, relative hum-idity=54±13%), almost reaching black flag conditions (28.0°C) throughout. Both groups were mildly dehydrated throughout pre-season with the HR group trending toward higher levels of dehydration (%BML=-0.79±0.30%, pre-practice $U_{col}$=5.7±0.7 shades, $U_{sg}$=1.023 ±0.004 µg) but the HR group was not significantly more dehydrated than the LR group (%BML= -0.73±0.70%, *p*=.789; pre-practice $U_{col}$=5.3 ±0.7 shades, *p*=.061; $U_{sg}$=1.021±0.004 µg, *p*=.087). Within practice variations in hydration status for the HR group (ΔBML= -0.82±.28 kg, $\Delta U_{col}$= 0.7±0.7 shades, $\Delta U_{sg}$=0.001±0.003 µg) were not significantly different than the LR group (ΔBML = -0.72±0.70 kg, *p*= .794; $\Delta U_{col}$ =0.9 ±1.0 shades,*p*=.445; $\Delta U_{sg}$ = 0.002± 0.003µg, *p*=.432). **Conclusions:** Although practicing in high risk environmental conditions and chronically mildly dehydrated throughout pre-season training camp, collegiate football players with risk factors for exertional heat illness were no more dehydrated than their lower-risk counterparts.

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**The Effect Of Individual Sodium Replacement On Fluid And Electrolyte Balance In NFL Players During Pre-Season Using Electrolyte Enhanced Fluids And Capsules**

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

**Context:** We previously replaced sodium in amounts equal to 50% of known sodium losses in NFL players during pre-season with excellent results. However, the fluids (Rehydralyte, Pedialyte, pickle juice and salt enhanced sugary fruit drinks) were not "healthy" or palatable. **Objective:** To individually replace sodium using all-natural, vitamin and sodium enhanced green tea and capsules in NFL players during the first week of two-a-days and measure blood electrolytes and changes in plasma volume (%ΔPV) and body mass (%Δmass). We hypothesized that except for increased PV no between-day differences would be found. **Design:** Observational cohort. **Setting:** Preseason training camps (2008 and 2009) of one NFL team. **Patients or Other Participants:** Seventeen NFL players (age=22±2.8y, ht=184.2±6cm, mass=106.4±15kg and BSA=2.29±0.2$m^2$) volunteered and 6 players participated in both years so data represent n=23. **Interventions:** Blood samples were taken for baseline measures when players' arrived to camp and prior to the morning practice on Days 3, 5 and 12. %"PV was calculated using Hct and Hb and blood electrolytes (sodium, potassium and chloride) were determined by ion-selective electrode. Baseline mass was recorded after urine samples (osmolality=511 ± 363 mOsm/kg) and (specific gravity =1.014 ± .009) ensured euhydration. %Δmass in the mornings of Days 3, 5 and 12 was calculated from baseline. On Days 1– 4 players practiced twice and then alternated 1 or 2 practices per day on Days 5 through 12. At meals players consumed sodium enhanced green tea and, sodium and vitamin capsules in amounts equal to 50% of their daily sweat sodium losses known from previous sweat testing. **Main Outcome Measures:** %ΔPV, %Δmass, blood sodium, potassium and chloride. One-way ANOVA with repeated measures were used. **Results:** Mean WBGT during practices for days 1–12 were 25.3±2ºC. Blood sodium was not different from baseline (141±2.6 mmol·$l^{-1}$) on Day3 (140.6±1.7 mmol·$l^{-1}$), Day5 (140±1.4 mmol·$l^{-1}$) or Day12 (139.5± .1mmol·$l^{-1}$), but PV increased significantly on Day3 (11.4% above baseline) and remained there on Day5 (11.3%) and Day12 (10.3%), *P*

= .001. No differences were found for blood potassium, chloride or %Δmass on the morning of Day3 (+.3%), Day5 (+.4%) and Day12 (+.3%). **Conclusions:** Blood sodium remained constant during the first 12 days of preseason training camp in NFL players who replaced 50% of their known daily sweat sodium losses using green tea and sodium capsules. Players maintained normal hydration as indicated by stable body mass in the morning of days 3, 5 and 12. The notable expansion and maintenance of plasma volume at 11% indicating normal acclimatization and fluid balance is clinically important as we have shown this not to be the case in un-supplemented players. Results support an individualized and all-natural, healthy method of fluid and electrolyte replacement for football players during training camp.

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**The Relationship Between Sodium Concentrations And Common Clinical Hydration Measures During Exercise**

Minton DM, Torres-McGehee TM, Emerson CC, Stacy J: The University of South Carolina, Columbia, SC

**Context:** Importance of maintaining proper electrolyte concentrations is continuously stressed to prevent hypohydration and decreases in performance, but there is no practical method for Certified Athletic Trainers (ATs) to measure sodium concentrations ($[Na^+]$). **Objective:** To examine the relationship between plasma $[Na^+]$, urine $[Na^+]$, and common clinical hydration measures of urine specific gravity ($U_{SG}$), urine color ($U_{col}$), and percent change in body mass (%ΔBM). **Design:** Randomized repeated measures design to elicit 6 experimental conditions: control (C), sodium depleted (S), hypohydrated (Hh), hypohydrated and sodium depleted (Hh+S), fatigue (F) and hyperthermia and fatigue (Ht+F). **Setting:** Exercise Science Research Laboratory. **Participants:** Sixteen moderately trained (training 3d/wk for ≥90min total), healthy volunteers (mean age= 28.13±6.82y, height=171.20±12.16cm, mass= 73.81± 15.21kg) participated in the study. **Interventions:** Participants completed a treadmill run to elicit the experimental condition (S, Hh, Hh+S, F, and Ht+F). Condition was verified through sodium, hydration, fatigue and core body temperature measurements. Once in the experimental condition the participants completed a lower extremity agility protocol. Sodium and hydration measures were taken again at the completion of the calf exercise protocol. Descriptive statistics were calculated for each dependent variable. Pearson *r* correlations were run for the overall data and within each experimental condition for all outcome measures. **Main Outcome Measures:** Plasma $[Na^+]$, urine $[Na^+]$, $U_{SG}$, $U_{col}$, and %ΔBM. **Results:** We found a significant correlation between $U_{SG}$ and $U_{col}$ ($r=0.831$, $p<0.001$) for all data and within all groups, but no correlation between plasma $[Na^+]$ and urine $[Na^+]$ or hydration measures overall. For C, urine $[Na^+]$ had high correlation to $U_{SG}$ ($r=0.742$, $p<0.001$). For F, there was a high correlation between plasma $[Na^+]$ and %ΔBM ($r=0.713$, $p=0.021$). $U_{col}$ had a high negative correlation with %ΔBM ($r=-0.759$, $p=0.001$) in the Hh condition. For S only urine $[Na^+]$ highly correlated with $U_{SG}$ ($r=0.890$, $p<0.001$). Lastly, for Hh+S urine $[Na^+]$ highly correlated with both plasma $[Na^+]$ ($r=0.719$, $p=0.019$) and $U_{SG}$ ($r$ 0.884, $p=0.001$). **Conclusions:** Due to limitations we were unable to determine a relationship between common clinical hydration measures and $[Na^+]$ during exercise. Currently, there remains no practical method for ATs to estimate $[Na^+]$ in athletes potentially at risk for exertional heat illness, exercise associated muscle cramping, and sodium depletion. Our results do support the continued use of $U_{SG}$ and $U_{col}$ to estimate hydration status in exercising individuals. Funded by the NATA Foundation Master's Research Grant Program.

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# Free Communications, Poster Presentations: New Technologies and Methods in Athletic Training

Thursday, June 24, 2010, 8:00AM-11:30AM, Grand Hall, authors present 10:30AM-11:30AM

**The Effect Of The Graston Technique On Pressure Pain Threshold**

Donahue M, Docherty CL, Schrader J: Indiana University, Bloomington, IN

**Context:** The Graston Technique (GT) is an instrument-assisted soft tissue mobilization technique based on the concepts of cross friction massage. The "brushing" treatment stroke used in the GT treatment protocol is proposed to desensitize the treatment area prior to more aggressive stages of the protocol. Pressure Pain Threshold(PPT) has been defined as the minimum transition point when applied pressure is sensed as pain. It has frequently been used to quantify soft tissue restrictions and associated discomfort. **Objective:** To determine the effect of GT's "brushing" stroke on PPT. **Design:** Pretest-Posttest Design. **Setting:** Research laboratory. **Participants:** Thirty age=22.48±2.28 years, height=173.54±10.11cm, mass=74.73±16.50kg) subjects, with no current lower body injury or history of sensory disorders were recruited from a university population. **Interventions:** The independent variables were treatment limb at two levels (control and treatment) and test site at two levels (site 1 and site 2). The treatment leg was randomly selected for all subjects. PPT was tested before and after participants received a 4-minute "brushing" only GT treatment to the posterior aspect of the lower leg. PPT values were recorded using a digital force algometer (Wagner Force One FDIX Force Gage Greenwich, Connecticut). PPT values were obtained from two sites on the lower leg. The first site (1) was directly over the Achilles tendon between the lateral and medial malleolus, the second site (2) was 10cm above site 1. The pressure plate of the algometer was held perpendicular to the testing site. Pressure was applied to the site through the rubber disk attached to the algometer. The subject was instructed to report when the sensation changed from 'pressure' to 'pain/ discomfort'. PPT values were obtained in kg/ $cm^2$, three readings were taken at each site and then the average was used to determine pretest and posttest values. **Main Outcome Measures:** PPT Delta change values (D) were then computed by subtracting PPT pretest value from PPT posttest value. Statistically, each test site was evaluated separately. A paired t-test was computed to determine the difference between the treatment and control limbs. **Results:** No significant difference was identified in PPT change values between the limbs at site 1 ($t_{29}=1.40$, $p=0.17$, DControl=0.31±0.95kg/$cm^2$, DTreatment=0.05±1.31kg/$cm^2$) or site 2 ($t_{29}=0.05$, $p=0.96$, DControl=0.24±1.02kg/ $cm^2$, DTreatment=0.22±1.36kg/$cm^2$). **Conclusions:** GT's brushing stroke was not able to desensitize either test site in a way that had a significant effect on PPT values. We believe this may be explained in two ways: 1) the "brushing" technique creates a superficial desensitizing effect at the skin level and the PPT is generally believed to measure pain at the muscular level, or 2) the technique used in this study treated a local area and did not

address the entire myofascial structure. These factors may have diminished any desensitizing effect that may be present.

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**An *In Vivo* Method For Estimating ACL Strain Via Motion Capture**

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

**Context:** Prospective evidence implicates excessive anterior tibial translation (ATT) as a risk factor for anterior cruciate ligament (ACL) injury, and greater ATT has been reported in populations at heightened injury risk. However, the magnitude of ATT may not accurately reflect ACL loading due to differences in ACL length between individuals. Strain quantifies the change in ACL length attributable to ATT relative to the initial ACL length (Dlength/initial length), but is difficult to evaluate without invasive methods. **Objective:** To evaluate the validity of a novel method for estimating *in vivo* ACL strain using motion capture techniques. **Design:** Cross-sectional. **Setting:** Research laboratory. **Patients or Other Participants:** Sixty-seven healthy, physically active volunteers (34 males: mass = 82.7 ± 15.0kg, height = 180.5 ± 7.5cm, age = 22.0 ± 3.1years; 33 females: mass = 61.8 ± 10.3kg, height = 164.1 ± 6.1cm, age = 21.8 ± 2.4years). **Interventions:** ATT was assessed by applying 20% body weight to the posterior shank via a custom-built perturbation device, and was defined as the difference in anterior displacements of electromagnetic motion capture sensors on the thigh and shank ($ICC_{2,1}$ = 0.98; SEM = 1.49mm). Previously reported regression equations were used to estimate initial ACL length as a function of height, and ACL elevation angle as a function of knee flexion angle. These values were incorporated in a biomechanical model to estimate the change in ACL length attributable to ATT. Apparent ACL strain (App_Strain) was calculated as the change in ACL length relative to the initial length. ACL strain was also estimated using a previously reported regression equation describing the relationship between ATT and *in vivo* strain obtained via a surgically implanted strain gauge (Reg_Strain). **Main Outcome Measures:** ATT, ACL length, and App_Strain were compared across sex via independent samples t-tests ($\alpha$0.05). The relationship between App_Strain and Reg_Strain was assessed via simple linear regression ($\alpha$0.05). **Results:** ATT (14.8mm vs. 8.5 mm; $p$ = 0.011) and ACL length (41.8mm vs. 34.2mm; $p$ < 0.001) were significantly greater in males than females. App_Strain did not differ across sex (29.1% vs. 21.4%; $p$ = 0.082). App_Strain and Reg_Strain were significantly correlated ($r$ = 0.983, $p$ < 0.001). **Conclusions:** ATT provides limited evidence for evaluating knee joint stability, as it does not account for the influence of ACL size, and therefore the loading status of the ACL. Our *in vivo* ACL strain model appears to be valid, as it is highly correlated with measures obtained via strain gauges surgically implanted in the ACL. These findings suggest that subject/patient size is an important consideration for evaluating joint stability as assessed via ATT. Future research is necessary to determine the utility of this model in evaluating ACL strain during dynamic tasks.

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**Compliance With Evidence-Based Football Face Mask Removal Recommendations In Clinical Athletic Training Practice**

Cappaert TA, Decoster LC, Hootman JM, Swartz EE: Central Michigan University, Mount Pleasant, MI; NH Musculoskeletal Institute, Manchester, NH; Centers for Disease Control and Prevention, Atlanta, GA; University of New Hampshire, Durham, NH

**Context**: The current recommendation for treating a football athlete with a potential head/neck injury is to fully remove the face mask prior to transport via emergency medical services (EMS). Face mask removal allows access to the athlete's airway, helps minimize motion and maintain a neutral cervical spine by leaving helmet and shoulder pads in place. It is not known to what extent athletic trainers are following these recommendations. **Objective:** To estimate prevalence of compliance to evidence-based guidelines regarding removal of football face masks prior to EMS transportation. **Design and Setting**: Cross-sectional, anonymous web-based survey (SurveyMonkey). **Participants:** NATA certified members in secondary school and college/university settings. The sample included all members who allowed emails for research purposes. Respondents (1884/6944, rate: 27%) were 36.0±9.7 years of age, 52% males and average year of certification was 1997±8.5. Although the response rate was low, there were no significant differences in the demographic characteristics of respondents compared to all secondary school and collegiate NATA members. **Interventions**: A new instrument was developed using the Table of Specifications approach and cognitively tested, including face validity, using a panel of 12 ATs currently working with football and an expert in survey methods. Test-retest reliability was assessed with 21 ATs taking the survey twice, 1 week apart; correlations ranged from .98-1.0. **Main Outcome Measures**: Prevalence (% and 95% confidence intervals [CI]) of football-specific EMS activation frequency and compliance with NATA guidelines for face mask removal (defined as removal of the face mask prior to EMS arrival). Chi Square and Cochran's Mantel-Haenszel tests were used to investigate the association between setting (secondary school vs. college), demographics (age, year of certification, sex, highest degree) and the outcome measures. **Results**: The 1884 respondents reported 586 episodes during the Fall 2008 football season where EMS was activated for a possible head/spine injury in a football player wearing helmet and shoulder pads. Significantly more secondary school ATs reported Fall 2008 football-related head/neck EMS activations than college ATs (59% vs. 27%; $X^2(30)=208.107$, $p<.001$; Odds Ratio [OR]=3.89 (95% CI 3.3-4.48)). In these cases, compliance with NATA guidelines was 57.7% (95% CI 53.7-61.8) overall and was significantly higher among collegiate ATs than secondary school ATs (70.5% vs. 54.9%; $X^2(1)=9.062$, $p<0.003$; OR=1.96 (95% CI 1.38-2.54)). There was no significant association between compliance to NATA guidelines for face mask removal and respondent age ($X^2(4)=2.409$, $p=0.661$), year of certification ($X^2(4)=1.114$, $p=0.892$), sex ($X^2(1)=3.483$, $p=0.062$) or highest degree (e.g., Bachelor's, Master's) attained ($X^2(2)=3.112$, $p=0.211$). **Conclusions**: Large disparities exist in compliance with evidence-based emergency care guidelines for treating suspected head/spine injuries in football athletes between secondary school and collegiate ATs. Future research needs to corroborate these preliminary findings and investigate the level of awareness and barriers to compliance in different practice settings.

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**Optimal Number Of Trials Required To Obtain Reliable Plantar Pressure Measurements Utilizing A Two-Step Approach**

Keenan KA, Akins JS, Dugan B, Abt JP, Sell TC, Lephart SM: Neuromuscular Research Laboratory, Department of Sports Medicine and Nutrition, School of Health and Rehabilitation Sciences, University of Pittsburgh, Pittsburgh, PA

**Context:** Dynamic barefoot plantar pressure measurements have been used widely in the assessment of the diabetic foot and, more recently, in the sports medicine setting to identify risk factors for lower extremity overuse injuries and footwear selection. Currently, there are no recommendations as to the minimum number of trials that should be collected in order to obtain reliable data. **Objective:** To assess the reliability of a pedographic platform and determine the optimal number of trials

necessary to obtain reliable plantar pressure measurements utilizing a two-step approach. **Design:** Reliability study. **Setting:** University sports medicine laboratory. **Patients or Other Participants:** Ten physically active males and females (age: 27.7±4.1yrs, mass: 77.6±10.7kg, height: 174.3±7.0cm) participated. Subjects reported no history of lower extremity surgery or injury during the six months prior to testing as well as no gait or balance disturbances. **Inter-ventions:** Dynamic barefoot plantar pressure measures were collected using the Emed-X pedographic platform (Novel, GmbH, Munich, Germany) during two sessions. Using a two-step approach and self-selected pace, 10 trials were collected for the right foot in each session. The foot was divided into 9 anatomical regions: medial hindfoot (MHF), lateral hindfoot (LHF), midfoot (MF), each metatarsal (MT1- 5), and the great toe (GT). Average mean pressure (AMP), force-time integral (FTI), peak pressure (PP), and pressure-time integral (PTI) were calculated for each region. Intraclass correlation coefficients (ICC) were calculated using a two-way random effects model (ICC [2, k]) for 10, 8, 5, and 3 trials. **Main Outcome Measures:** ICC values from two-way random effects model. **Results**: Across all number of trials, ICCs ranged from 0.80- 0.99 (SEM: 1.25-9.60kPa) for AMP, 0.78- 0.97 (SEM: 1.27- 7.82N*s) for FTI, 0.70- 0.97 (SEM: 9.80- 96.93kPa) for PP, and 0.62- 0.96 (SEM: 4.36- 36.14kPa*s) for PTI. Across all regions and for all variables, 5 trials demonstrated the best consistency (ICC, SEM)- AMP: 0.851- 0.99, 1.25- 6.27kPa; FTI: 0.86- 0.97, 1.27- 4.2N*s; PP: 0.83- 0.97, 9.80- 35.85kPa; PTI: 0.80- 0.95, 4.36- 12.01kPa*s. LHF, MT1, MT2, and GT were found to be the most reliable as indicated by ICCs e•0.80 across all trials and all variables. **Conclusions:** Reliable measurements of AMP, FTI, PP, and PTI can be obtained using the pedographic platform and a two-step approach. In order to obtain maximum reliability of the measures, 5 trials should be collected. This information should be used to guide dynamic plantar pressure assessments in both research and clinical settings.

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**Time, Head Movement, and Helmet Movement During Emergency Airway Access Techniques in American Football**

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**Context:** Medical professionals are faced with the challenging task of gaining airway access in football players with possible cervical spine injuries quickly while limiting head movement. Prolonged time to gain airway access delays oxygen delivery and may allow for excess head movement causing secondary spinal cord injury. Inline stabilization is performed with the intention of limiting helmet movement, but may not be adequate in minimizing movement at the head. **Objective:** To determine if total linear head movement (HdMvmt) and total linear helmet movement (HelMvmt) increase as time to airway access increases during three different airway access techniques; and to determine if a relationship exists between HdMvmt and HelMvmt in three airway access techniques. **Design:** Prospective counterbalanced design. **Setting:** Sports medicine research laboratory. **Participants:** Thirty-six participants volunteered for this study, including 18 clinically active Certified Athletic Trainers employed by a varsity athletics program or enrolled in an accredited graduate Athletic Training program (ATCs; 3.75±3.95 years certified, 2.67±3.18 seasons working football) and 18 non-certified students enrolled in an accredited undergraduate athletic training education program (NCS; 2.5±1.36 semesters in program, 0.92±0.73 seasons working football). **Interventions:** All participants completed one trial of each of the three following airway access techniques: face mask removal of a helmet with a quick release mechanism (QRM), traditional facemask removal with a cordless screwdriver (CSD), and pocket mask insertion between the chin and facemask (PMI). A three-dimensional electromagnetic tracking system was used to record kinematics of the head and helmet. **Main Outcome Measures:** Time (sec), HdMvmt (cm), and HelMvmt (cm) were calculated. Pearson correlation coefficients were calculated between time, HdMvmt, and HelMvmt for each technique. **Results:** There was a negative linear relationship between time (50.37±13.12) and HdMvmt (44.24±5.64) during the QRM technique ($r$= -0.299, $P$=0.077). No relationships existed between time and HdMvmt during the CSD ($r$=0.113, $P$=0.510) and PMI techniques ($r$=0.213, $P$=0.213). No relationships existed between time and HelMvmt during any of the three airway access techniques (QRM:$r$=-0.223, $P$=0.191; CSD:$r$=0.046, $P$=0.788; PMI:$r$=-0.118, $P$=0.494). A positive linear relationship was observed between HdMvmt (44.24±5.64) and HelMvmt (30.52±4.39) during the QRM technique (r=0.437, $P$=0.008). No relationship existed between HdMvmt and HelMvmt during the CSD (r=0.242, $P$=0.154) and PMI technique (r=0.183, $P$=0.284). **Conclusions:** Extended time taken to access the airway does not result in greater head movement. If the airway of a football player with a potential cervical spine injury is not compromised, caution can be taken to carefully remove the facemask without fear of increasing overall head movement. No single technique results in the head and helmet moving together congruently, but helmet movement is most closely correlated with head movement during the QRM technique. Our data suggest that clinicians should not assume that manual inline stabilization of the helmet fully immobilizes the head.

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**Reliability Of The Ligmaster Computerized Stress-Arthrometer For Assessment Of Valgus Elbow Laxity And Stiffness**

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**Context**: The ulnar collateral ligament (UCL) is the primary ligamentous restraint providing valgus stability to the elbow. The valgus forces imposed by overhead throwing approach those observed with complete UCL failure. Attenuation and rupture of the UCL are common injuries in baseball pitchers and result in significant disability. Computerized stress arthrometry is a non-invasive clinical method that can be utilized to measure valgus elbow laxity and stiffness that may prove useful for diagnosing UCL injury. **Objective:** To evaluate the within and between session intra-rater reliability of the LigMaster (Sports Tech, Charlottesville, VA) computerized stress-arthrometer for measurement of valgus elbow laxity and stiffness. **Design:** Repeated measures. **Setting:** Division I Athletic Training Facility. **Patients or Other Participants:** Twenty five (13 M, 12 F) Division I collegiate athletes (20.5+1.4 years, 182.9+13.8 cm, 94.1+31.5 kg) from a variety of sports were recruited from a sample of convenience. The exclusion criteria included athletes who had sustained an injury to their

elbow and/or shoulder in the past 6 months and athletes who had ever undergone an UCL reconstruction procedure. **Interventions:** A single investigator utilized the LigMaster computerized stress arthrometer to assess valgus elbow laxity and stiffness during two testing sessions that were conducted 48-hours apart. Within session reliability was determined by comparing the data from two repeated trials [ICC (2,1) and SEM] within the same testing session. Between session reliability was evaluated by comparing the average of the two trials taken during the two separate testing sessions that occurred 48 hours apart [ICC (2,k) and SEM]. **Main Outcome Measures:** Laxity (mm) was calculated as the average magnitude of displacement recorded between the calculated inflection point and the terminal displacement point recorded at 120 N of force. Stiffness (N/mm) was calculated by dividing the average magnitude of force (N) recorded between the calculated inflection point and the terminal force applied (120 N) by the average displacement (mm) across the same range. **Results:** Means±SD were as follows: Session 1 laxity = 13.6±5.9 mm, stiffness = 4.5±1.5 N/mm; Session 2 laxity = 14.2±5.9 mm, stiffness = 4.5±1.8 N/mm. The LigMaster demonstrated excellent within-session intra-rater reliability and precision for both laxity (ICC = 0.96; SEM = 1.24 mm) and stiffness (ICC = 0.91; SEM = 0.48 N/mm) and excellent between-session intra-rater reliability and precision for both laxity (ICC = 0.92; SEM = 1.63 mm) and stiffness (ICC = 0.91; SEM = 0.64 N/mm). **Conclusions:** The LigMaster demonstrated excellent within- and between-session intra-rater reliability and precision for measuring valgus elbow laxity and stiffness. Future studies are needed to establish the value of this measurement tool for diagnosing disruption of the UCL.

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### Validity Of A Cost Effective Tool For Clinically Assessing Lower Extremity Muscle Strength

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**Context:** Clinicians need efficient, cost effective assessment tools to determine the efficacy of rehabilitation and prevention programs. Isokinetic dynamometers (IKD) have been suggested to be the "gold standard" when assessing lower extremity strength; however, they may not be affordable to all clinicians. Hand-held dynamometers (HHD) may provide a more efficient and cost effective method to assess lower extremity strength. It is unknown whether HHD produces valid measurements of lower extremity strength. **Objective:** To determine the relationship between a HHD and an IKD in assessment of lower extremity strength. **Design:** Repeated measures design. **Setting:** Laboratory setting. **Participants:** One hundred and four (47M, 57F) healthy participants (21.8±2.5yrs, 170.5±11.0cm, 70.6±13.8kg). The population represents a combined sample from three previous studies that assessed hip strength (N=37), thigh strength (N=30), and ankle strength (N=37). **Interventions:** Hip, thigh and ankle strength were measured during maximal isometric contractions with a HHD (Lafayette Instruments, Lafayette, IN) and an IKD (Biodex Medical Systems Inc, Shirley, NY). IKD hip strength was recorded during hip abduction (standing, hip abducted 5°), external rotation (semi-reclined, hip flexed 40°, knee flexed 90°) and extension (supine, hip flexed 90°). IKD knee extension and flexion strength was recorded in a seated position (hip and knee flexed 90°). IKD ankle inversion and eversion strength was recorded in a seated position (70° tilt, knee flexed 30-45°). HHD hip strength was recorded following the IKD procedure. HHD thigh and ankle strength was recorded using standard manual muscle testing procedures. Single investigators performed all HHD measures for their respective studies and were blinded to collected data. The highest peak torque over 3 trials for each strength measure was used for analyses. Pearson correlations (r) determined the relationship between the HHD and IKD strength measures. **Main Outcome Measures:** HHD strength measures were recorded in kilograms (kg) of force while IKD strength measures were recorded in Newton-meters (Nm) of torque. **Results:** Means±SDs for each strength measure (HHD/IKD) are as follows: hip abduction (14.8±5.4 kg / 46.3±14.6 Nm), hip external rotation (16.7±4.8 kg / 60.0±22.6 Nm), hip extension (51.8±16.3 kg / 288.6±84.2 Nm), knee extension (32.4±6.0 kg / 172.1±42.2 Nm), knee flexion (26.7±7.1 kg / 106.4±26.9 Nm), ankle eversion (12.3±2.5 kg / 13.1±5.2 Nm), and ankle inversion (15.4±2.8 kg / 15.4±8.1 Nm). Moderate to strong relationships (all $P<.001$) were observed between HHD and IKD strength measures. The highest correlation was observed with measures of hip external rotation (r=.773), followed by knee extension (r=.753), hip extension (r=.722), hip abduction (r=.634), ankle eversion (r=.618), ankle inversion (r=.513)and knee flexion (r=.506). **Conclusions:** Moderate to strong relationships were observed between HHD and IKD strength measures of lower extremity muscles. These results suggest the HHD may be a cost efficient tool for assessing lower extremity muscle strength.

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### Stability Of Human Performance Measurements Commonly Implemented In Mouthguard Related Crossover Designs

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**Context:** Several mouthguard manufacturers have been recently vying for athletic training budget dollars by marketing MORA (mandibular orthopedic repositioning appliance) products which claim to enhance aspects of human performance (strength, concentration, coordination, reaction time, dexterity, and balance). As such, research regarding the efficacy of these effects is on the rise. The crossover design (with washout period) coupled with strength, dexterity and balance measures have emerged as the leading method of inquiry. Therefore, evidence of test-retest stability of these scores over washout time is warranted. **Objective:** To analyze the 10-day test-retest reliability of human performance measures commonly implemented in mouthguard/MORA crossover studies. **Design:** A prospective, A/B B/A crossover design with a 10 day period washout period. **Setting:** A controlled laboratory setting. **Patients or Other Participants:** Twenty-seven healthy, physically active volunteer male students (age=21.3±2.2 yr; ht=177.1±7.2 cm; mass= 85.8±3.4 kg) enrolled in a southeastern Division I institution. **Interventions:** Subjects completed informed consent and a brief health history questionnaire and were group matched on age, height and weight. Aforementioned human performance conditions were tested via the following battery: dominant and non-dominant hand Grip Strength (GS) measured in kilograms; dominant and non-dominant hand Grooved Peg Board Test (GPBT) measured in seconds, Just Jump (Probotics, Inc., Huntsville, AL) vertical jump (VJ) hang time (seconds) and height (inches), and the Biodex Balance System SD (Biodex Medical Systems, Inc., Shirley, NY) overall (OSI), anterior-posterior (APSI), and medial-lateral (MLSI) indices. The Shrout and Fleiss (2,1) method was used to calculate 9 intraclass correlation coefficients (ICCs) between the sessions. **Main Outcome Measures:** Mean square values for between subjects (BMS), error (EMS), and trials (TMS) were calculated from the various human performance data. **Results:** All ICCs were statistically significant except for the dominant grooved pegboard test. The dominant hand GS yielded an ICC of (R=.79; 95% CI, 0.58-0.89) while the non-dominant hand GS yielded an ICC of (R=.82; 95% CI, 0.64-0.91). The dominant hand yielded an ICC of (R=.24; 95% CI, -0.14-0.57) while the non-dominant GPBT yielded an ICC of

(R=.35; 95% CI, -0.03-0.64). The VJ hang time yielded an ICC of (R=.93; 95% CI, 0.85-0.97) while the VJ height yielded an ICC of (R=.93; 95% CI, 0.86-0.97). The balance indices OSI yielded an ICC of (R=.740; 95% CI, 0.51-0.87); APSI yielded an ICC of (R=.739; 95% CI, 0.51-0.87); and MLSI yielded an ICC of (R=.743; 95% CI, 0.51-0.87). **Conclusions:** The marginal/high score stability, demonstrated by balance, grip and vertical jump data respectively, provide support for the use of these measures in the crossover design when looking at the effects of mouthguards with MORA. Conversely, low score stability, demonstrated by the GPBT test data, does not provide support for inclusion of this human performance measure.

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**Microvascular Perfusion Measurement In The Human Triceps Surae With Contrast Enhanced Ultrasound At Rest**

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**Context:** Despite the interest in studying microvascular responses in musculoskeletal injuries, techniques to visualize and accurately measure capillary blood flow in skeletal muscles have only recently been developed. Contrast enhanced ultrasound (CEU) has been used to assess cardiac and skeletal muscular perfusion, but not in the weight bearing muscles of humans. **Objective:** To determine the intra and inter tester reliability and the day to day variability of CEU measures of blood flow and volume in the human triceps surae at rest. **Design:** Test-retest. **Setting:** Laboratory. **Subjects:** Five healthy, fasting volunteers (1M, 4F; 24.2±2.6y, 73.5±10.8Kg, 167.6±16.7cm) who refrained from exercise for 12 hours. **Methods:** Subjects underwent baseline CEU measures on 2 separate days. The right medial head of the gastrocnemius muscle was imaged with ultrasound (P4-2 phase-array transducer, HDI-5000, Philips Ultrasound, 8MHz). The contrast agent Definity® microbubbles (Bristol Myers-Squibb Imaging, North Ballerina, MA) was mixed with saline and infused intravenously at a rate of 1.5 $ml \cdot min^{-1}$. Images were obtained at pulsing intervals (PI) from 0.2 to 20 seconds coordinated with electrocardiogram. To isolate the signal from the microvasculature, images obtained at intervals between 0.2 and 1 second, representing large vessels, were used as baseline images and digitally subtracted from the images at longer PIs. The PI versus the video intensity was fit to the function: $y=A(1-e^{-\beta t})$. Calculations were made where y is the acoustic intensity (dB representing flow) at the pulsing interval *t*, *A* is the plateau acoustic intensity, and b is the rate constant. *A* reflects the total microvascular blood volume and b reflects the red blood cell velocity. A region of interest was chosen from saved images and analyzed with Philips Qlab software. **Main Outcome Measures:** Intra and inter rater reliability was evaluated using intraclass correlation coefficients (ICC) of values obtained by 2 separate investigators. The bloodflow value *y* from the CEU function were then analyzed using ICCs to compare baseline bloodflow values between days. **Results:** Intrarater reliability ICC (2,1)= .98; CI=(.91-.99), (mean±sd; a) 6.7± 3.0 dB; b) 6.6 ± 3.1 dB). Interrater reliability ICC (2,1)= .96; CI=(.87-.99) a) 6.8 ± 2.8 dB; b)6.6 ± 3.1 dB). The baseline measurements of bloodflow variability ICC (2,1)=.69, CI = (-.28-.96) a) 7.4± 6.81dB; b) 6.68 ± 6.56 dB ). **Conclusion:** The technique of determining bloodflow CEU characteristics was consistently measured within and between investigators. However, the baseline measures in the gastrocnemius bloodflow between days were variable. Variability in resting bloodflow may be affected by diet, exercise status including walking, temperature and other endocrine functions. Changes in skeletal muscle bloodflow as a result of an intervention should be compared to a measured baseline value on the day of an acute intervention rather than relying on a single baseline measurement for all comparisons.

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**The Effect Of Transcranial Magnetic Stimulation On Volitional Quadriceps Activation In Post-Operative Partial Meniscectomy Patients**

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**Context:** Quadriceps activation deficits have been reported following meniscectomy. Transcranial magnetic stimulation (TMS), in conjunction with maximal contractions has been reported to increase voluntary activation of the quadriceps in healthy subjects and patients following total knee arthroplasty. It remains unknown how TMS will affect quadriceps activation in post meniscectomy patients. **Objective:** To determine the effect of single-pulsed TMS on quadriceps central activation ratio (CAR) in post-meniscectomy patients. **Design**: Single blinded, randomized laboratory experiment. **Setting**: University laboratory. **Participants:** Twenty participants with a history of arthroscopic partial meniscectomy and quadriceps activation less than 85% were randomly assigned to the TMS group (7 male, 4 female, 38.1 ± 16.2 years, 176.8 ± 11.5cm, 91.8 ± 27.5kg, 36.7 ± 34.9 weeks post-op) or the control group (7 male, 2 female 38.2 ± 17.5years, 176.5 ± 7.9cm, 86.2 ± 15.3kg, 36.6 ± 37.4 weeks post-op). **Intervention:** The independent variables in this study were treatment group and time. Participants in the experimental group received TMS over the contralateral motor cortex in conjunction with 3 maximal quadriceps contractions. Prior to TMS, the optimal positioning of the stimulating coil was located by identifying the highest corresponding motor evoked potential in the vastus lateralis. The control group performed 3 maximal quadriceps contractions without the TMS. A 2x5 analysis of variance with repeated measures on time was performed to determine differences in treatment group over time for CAR. Standardized effects sizes were calculated at each posttest and an *a priori* level of significance was set at $P \leq .05$. **Main Outcome Measures**: Quadriceps activation was assessed with the CAR, which was measured in 70°of knee flexion at baseline, immediately following (0-min) and at 10, 30, and 60 minutes post treatment. CAR was expressed as a percentage. **Results**: Significant differences in CAR ($F_{4,72}$= 3.0, *P*=.02) were detected over time, yet, no significant interaction or between groups differences were found for CAR. CAR scores tended to increase over time in the TMS group (baseline: *70.1±11.6*, 0: *74.0±12.4,*10: *76.0±10.3,* 30: *75.1±10.7,* 60: *75.8±11.3*) compared to the control group with the exception of the 30 minute posttest seemed to remain stable (baseline: *74.5±10.5*, 0: *75.2±7.8,*10: *75.3±9.4,* 30: *78.0±9.3,* 60: *75.0 ±11.0*). Strong effect sizes were seen for CAR at 10 (Cohen's d=0.82; 95% CI -.13, 1.7), and 60 minutes (Cohen's d=1.06; 95% CI .08, 1.95). **Conclusions**: No significant differences in CAR were found between the TMS and control groups. Although significant differences were not seen between groups immediately following a single treatment, strong effect sizes in CAR following TMS at 10 and 60 minutes provide evidence that underlying potential clinical benefits to TMS enhanced contractions should explored in future research.

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**The Effect Of Custom Molded Orthosis Intervention On Walking Gait Kinetics**

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**Context:** Although the effectiveness of FO intervention is well accepted clinically, quantitative studies investigating the mechanical effects of FOs have yielded inconsistent results. Factors related to the inconsistent results may include variability of both the FOs utilized and the participants receiving intervention. Foot orthoses are designed to correct abnormal mechanics, therefore, investigating the effect of intervention in persons with abnormal foot posture may be important. **Objective:** Investigate the effect of balanced (BFO) and full contact (FCO) custom molded FO intervention on walking gait kinetics in participants with low-mobile foot posture. **Design:** A mixed-model repeated measures design. **Setting:** Controlled, laboratory setting. **Participants:** Sixteen participants with low mobile foot posture (m=7, f=9, age=25.4 ±6.3 years, mass=73.9 ±14.8 kg, height =173.0 ±11.0 cm), no history of lower extremity surgery, and free from lower extremity injury within the previous six months participated in the study. **Methods:** Arch height and foot mobility were quantified using the arch ratio and the relative arch deformity ratio, respectively. Participants were then randomly assigned to a BFO, that provided support via forefoot and rearfoot posting, or a FCO, that provided support through the medial longitudinal arch with no posting. An AMTI force platform (Advanced Mechanical Technology, Newton, MA) mounted within a 10 m walkway and sampling at 960 Hz was used to measure ground reaction force (GRF) data as participants completed five walking trials (1.3-1.4 m/s) during a no FO ((-)FO and FO ((+)FO condition. A custom software program was then used to normalize GRF data to body weight and ensemble average each participant's five gait trials. Three-dimensional peak forces during stance were then computed. **Main Outcome Measures:** Independent variables included a between subject variable (group: BFO,FCO) and a within-subject variable (insert condition: (-)FO, (+)FO) and dependent variables were the peak forces during stance. Repeated measures ANOVAs ($\alpha<0.05$) were performed to investigate between group and insert condition kinetic differences. **Results:** ANOVA results revealed a significant group by insert condition main effect for peak anterior force (p=0.008) and a significant insert condition main effect for the first vertical force peak ((-)FO:1.16 ±0.04 N/BW; (+)FO:1.19 ± 0.08 N/BW; p=0.003). Follow-up analysis of the group by insert interaction did not reveal significant differences between the (-)FO and (+)FO conditions for either the BFO ((-)FO:0.23 ± 0.03 N/BW; (+)FO:0.24 ± 0.03; p=0.072) or FCO ((-)FO:0.24 N/BW ± 0.03; (+)FO:0.23 ±0.03; p=0.537) orthoses. **Conclusions:** Our results suggest walking gait kinetics are significantly affected by BFO and FCO orthoses. The significant increase in the first peak force may be the result of the FOs stabilizing the low-mobile foot posture. If so, the orthoses may facilitate unloading of the dynamic stabilizers that may otherwise be associated with increased risk of repetitive stress related lower extremity injury.

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**Development Of A Fiber Optic Sensor For Measuring Tension Force In Connective Tissue**

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**Context:** Measuring tension forces in connective tissues is a useful technique in orthopaedic and sports medicine research. A fiber optic method of accomplishing this in large, superficial tendons has been reported. However, the technique is too invasive for use in other tissues (e.g., ankle ligaments). This creates an opportunity for development of a less invasive device that has potential for both *in vitro* and *in vivo* applications. **Objective:** To develop and test an innovative fiber optic sensor to measure tension force that eventually could be applied in connective tissues. **Design:** Prototype bench testing. **Setting:** Laboratory. **Device:** Proprietary fiber optic sensor. **Interventions:** A fiber optic transmitter and receiver system was designed and produced using a 660 nm visible red LED. A proprietary fiber optic sensor fit to this system also was designed and produced. A 6-inch length of nylon rope was utilized to represent a ligament. The rope was affixed in a Zwick-Roell Z020 material testing unit, and the proprietary fiber optic sensor was embedded in the rope, perpendicular to the rope's length and through its diameter. Data were collected by a National Instruments USB-6009 data acquisition device and SignalExpress datalogging software. A tension of 10 N was applied to the rope for 1 minute in order to allow stabilization of the sensor's bias to 0. The rope was then stretched at 100 N/s until the load reached 1000 N. During the tension testing, voltage measured by the sensor was recorded at a sampling frequency of 250 kHz. This protocol was repeated for a total of 5 trials. Then the rope was subjected to 6 stretch rates ranging from 50 to 377 N/s. Voltage data were collected as previously. **Main Outcome Measures:** Voltage change (proportional to tension force per the Poisson ratio) **Results:** The 5 trials performed on the rope yielded identically shaped linear V/t curves. The initial trial was identical in slope, but of slightly lower magnitude than the remaining 4 trials. The V/t curves for trials 2-5 were virtually superimposed. Mean maximum voltage upon reaching the 1000 N load was 5.7±0.25 V. At each successively increasing stretch rate, the V/t graphs displayed approximately identical shapes; their slopes were increasingly greater. These results showed that, as expected, maximum load was reached more quickly and the nylon rope was a repeatable test model. **Conclusions:** The invented fiber optic sensor tested in this study operates as it was designed in a nylon rope model used as a precursor to the sensor's use in connective tissue. The device offers repeatable voltage output results that correspond to increasing tension in the rope. This is a successful inception of a series of studies to innovate a fiber optic sensor for use in orthopaedic tissue biomechanics. Funded by the NATA Foundation Doctoral Research Grant Program.

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**The Influence Of Leg Dominance On Coordination During A Closed-Chain Tracking Task**


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**Context:** The Monitored Rehabilitation Functional Squat System (MRFSS) provides objective feedback on closed-chain activities and has been found to be accurate, valid, and reliable. Clinicians often compare an injured limb to a non-injured limb as a measure of progress for patients undergoing rehabilitation. Knowledge of inherent differences in coordination based on leg dominance is critical to helping the clinician set appropriate outcome goals. **Objective:** To determine if healthy dominant and non-dominant legs have comparable coordination. **Design:** Single group, repeated measures. **Setting:** Outpatient clinic. **Participants:** Convenience sample of 21 males (age 26.4±4.7; height 177.9±5.6cm; weight 81.5±14.9kg; visual acuity left 20/24.8, right 20/25.8) recruited from an adult recreation league. Exclusion criteria included past ACL injury, current lower extremity injury and central nervous system pathology. **Interventions:** After providing consent, participants' height, weight and visual acuity were measured (Sloan eye chart) then participants performed a five-minute unresisted stationary-bike warm-up. Leg dominance was assessed with 3 tests (ball kick, step-up, jump-landing) and the leg used for 2 or 3 of the tests was considered dominant. Participants were blinded to the study's dominance component; they were simply asked to perform the tasks. The MRFSS was adjusted so participants started each test with their knee flexed between 90°-100° and hip flexed between 85°-95°. Foot placement on the footplate was marked with tape to ensure consistency throughout testing. MRFSS resistance was set at 10% (to the nearest 5kg) of body weight. Scripted instructions were read. Participants acclimated to the leg-press-like apparatus by sliding the sled through flexion and extension of the knees and hips bilaterally. Participants were positioned with the test foot flat on the footplate, arms crossed on the chest and non-test foot on the adjacent footrest. The MRFSS monitor was visible to the participant. During each trial a consistent path was displayed on the monitor; participants had to flex or extend lower extremity joints to keep the computer cursor positioned on the path. Participants completed eight 60-second trials per leg with 60 seconds of rest between trials. Leg test order was randomized. Mean results of trials 5-8 (to minimize effects of learning) for both dominant and non-dominant legs were compared using a paired samples t-test. **Main Outcome Measure:** Tracking accuracy (i.e., distance from target path (mm)) as measured by the MRFSS software. **Results:** The mean distance from the target for dominant limbs was 4.53±0.89mm and for non-dominant limbs 4.56±0.81mm ($t_{(19)}$=.27, $p$=0.79). **Conclusions:** There was no significant difference in tracking accuracy between dominant and non-dominant legs. The objective representation of coordination in this tracking-accuracy task supports the appropriateness of using the non-injured limb as the standard for comparison when goal-setting or measuring progress for those undergoing rehabilitation.

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**Changes In Balance Performance Following Basketball Pre-Season Conditioning**


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**Context:** Previous research has reported improvements in balance following strengthening programs in geriatric populations and following rehabilitation of pathological conditions. Recent research, however, questions this relationship in highly trained individuals as it has been suggested that increased strength is negatively correlated with balance measures. **Objective:** To determine the effect of pre-season conditioning on changes in balance in collegiate level basketball athletes. **Design:** A two group pre-post test study. **Setting:** Research laboratory. **Participants:** Sixteen NCAA Division I collegiate basketball (BB) players (19.8±1.6yrs, 86.9±12.6kg, 188.9±11.5cm) and sixteen healthy, non-basketball control (CNT) participants (21.1±0.9yrs, 72.9± 12.6kg, 172.4±9.0cm) participated in this study. **Interventions:** Baseline measures on the Star Excursion Balance Test (SEBT) were recorded prior to pre-season conditioning. The basketball group then underwent a 6-week conditioning intervention designed, implemented and monitored by a certified strength and conditioning coach with the goal of improving strength, power, and agility. Follow-up testing occurred at the conclusion of pre-season conditioning. Differences in normalized reach distance were present between groups at baseline, thus, Analyses of Covariance on the follow-up testing were implemented with the baseline values used as covariates. An alpha level of 0.05 was utilized for all analyses. **Main Outcome Measures:** SEBT measures in the anterior, medial, and posterior directions were recorded from the dominant limb (based on kicking preference) during SEBT performance on a stable surface. Values from all directions were averaged to provide an overall reach score. All reach distances were normalized to reach leg length (cm). **Results:** Post-intervention reach performance declined in all directions for the basketball group and in the posterior and overall reach for the control group. Between group ANCOVA results were significant ($p<.05$) in the anterior (BB=.91±.08cm, CNT=1.03 ±.07cm, $p<.01$), medial (BB=.90±.10cm, CNT=1.02±.06cm, p=.02) and overall reach scores (BB=.87±.08cm, CNT=.98±.06cm, p=.02). Comparison of means indicated the basketball group's reach scores decreased 4-5% in all directions following 6 weeks of pre-season conditioning. **Conclusions:** Following pre-season conditioning, reach distances in the basketball group were significantly less than the control group. Recent literature has suggested that improved conditioning may negatively affect reach distance as measured by the SEBT. Consistent with this suggestion, it is possible that the current findings are related to changes in muscle function induced by the pre-season conditioning program. The utility of using baseline SEBT performance as a tool for detecting changes in lower extremity injury risk across a competitive sport season may be further complicated by alterations in conditioning status.

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**Alterations In Postural Control Following An Acute Bout Of Soccer Heading**


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**Context**: Soccer athletes head the ball regularly during play. Previous studies utilizing postural assessments to evaluate neurophysiological functioning after heading have indicated no decrements. None of the assessments, however, incorporated dynamic environmental conditions and may not have been challenging enough to illuminate an injury. **Objective**: To determine if an acute bout of

heading adversely affects postural control. **Design**: Repeated measures randomized control. **Setting**: University Athletic Training and Virtual Environment and Postural Organization Laboratories. **Participants**: A convenience sample of 16 volunteers (experimental group [EG] n = 8, age = 21.24±1.98 yrs, height = 173.04±9.15 cm, and mass = 70.51±9.87 kg; control group [CG] n = 8, age = 22.63±2.56 yrs, height = 180.34±9.11 cm, and mass = 75.61±13.37 kg) with at least 5 years of soccer heading experience. **Intervention**: Independent variables were group (EG vs. CG), time (pre-test; 1, 24, and 48 hrs post-test), and postural trial (stationary virtual environment [VE] with stationary support surface, dark condition with moving support surface, a rotating VE with stationary support surface, rotating VE with moving support surface, a dark condition with stationary support surface, and stationary VE with a moving support surface). Participants were randomly assigned to a group and either simulated or performed 10 headers in 10 min (ball velocity 11.2 m/s). The postural assessment consisted of six 30 s trials. Data were analyzed using four separate 2 (group) x 4 (time) x 6 (postural trial) analyses of variance (ANOVA) using SPSS 17.0 ($p \leq .05$). **Main Outcome Measures**: The root mean square (RMS) of the center of mass (COM) and the Approximate Entropy (ApEN) of the center of pressure (COP) were calculated for the medial-lateral (ML) and anterior-posterior (AP) directions using custom written Matlab (MathWorks Inc., Natick, MA) scripts. **Results**: The ML COM RMS ANOVA indicated a significant group by time interaction, $F(2,166) = 4.384$, $p = .005$. The EG ($6.91\pm.42$; $7.19\pm.44$) was 26 and 41% higher than the CG ($5.47\pm.42$; $5.09\pm.44$) at hr 1, $t(94) = -2.06$, $p = .042$, and 24, $t(94) = -2.55$, $p = .013$, respectively. The ML COP ApEn ANOVA indicated a significant group by time interaction, $F(2,166) = 6.831$, $p = .001$. The EG ($.587\pm.023$) was 17% lower than the CG ($.704\pm.023$) at hr 24, $t(94) = 2.829$, $p = .006$. The AP COP ApEn ANOVA indicated a significant group by time interaction, $F(2,166) = 6.035$, $p = .003$. The EG mean ($.572\pm.027$) was 15% lower than the CG (.672+.027) at hr 24, $t(94) = 3.183$, $p = .002$. **Conclusions**: An acute bout of heading resulted in quantifiable postural control alterations 1 to 24 hours after heading. The significant findings are contrary to the acute heading literature and may be due to the postural assessment's robust dynamic environmental conditions.

# Free Communications, Poster Presentations: Case Reports Poster

Thursday, June 24, 2010, 8:00AM-11:30AM, Grand Hall, authors present 10:30AM-11:30am

**Femoral Neck Stress Fracture In A Female Soccer Player**

Gray CE, Scriber KC, Geisler PR:
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**Background**: A 19 year old female collegiate soccer player reported for the 2009 pre-season with a pre-existing adductor strain that had occurred 7 days earlier during summer conditioning. Initially her evaluation confirmed this injury and her practice activities were limited for 7 days while she received treatment and did strengthening exercises. She was progressed back to full activity using an elastic spica wrap for support without incident. Ten days after returning to full practice, she experienced significant pain in her groin during repetitive cutting and jumping drills. She indicated her pain was different than previously described, now being deeper and across the inguinal line, resulting in a pinching sensation with hip flexion and/or internal rotation. Palpation failed to elicit pain and AROM was normal and pain-free, but pain was noted with PROM when moved into end range positions. Her pain was greatest with combined passive hip flexion, adduction and internal rotation. She denied pain when asked to perform a single leg hop on the involved side. **Differential Diagnosis**: acetabular labral tear, femoral acetabular impingement syndrome, ligamentum teres sprain, athletic pubalgia, iliopectineal bursitis, ilioinguinal nerve entrapment. **Treatment**: The athlete was referred the next day to the team physician who ordered x-ray and an MRI with contrast to rule out labral pathology. The radiologist read the x-ray as normal but MRI indicated a non-displaced incomplete stress fracture in the inferiomedial margin of the femoral neck. Because this injury was on the compression side of the femoral neck as opposed to the tension side, she was treated conservatively and was instructed to be NWB on crutches for 2 weeks. Follow up x-ray was ordered and confirmed the fracture site had begun healing and remained non-displaced. The athlete was progressed to PWB on crutches and at 4 weeks an x-ray was repeated. After a total of 5 weeks NWB she was able to begin ambulating without crutches and aquatic therapy. At 7 weeks post diagnosis she was cleared to start jogging and began to slowly progress towards functional activities. Currently it is expected that she will participate in spring 2010 practice sessions. **Uniqueness:** Femoral neck stress fractures are fairly uncommon type of stress fracture seen in the adolescent population and account for only 5-10% of all stress fractures. They are often difficult to diagnose on exam because of the non-specific findings and the many possible differential diagnoses that must be considered. In this case, an atypical pattern presented itself due to the fact that some of the key features of a femoral neck stress fracture were not present: pain over the greater trochanter, pain when performing a single leg hop, or a gradual onset of dysfunction. Her symptoms of pain with hip flexion, adduction, and internal rotation and complaints of a pinching sensation were more consistent with an acetabular labral injury, or femoral acetabular impingement. **Conclusion**: It is important for athletic trainers to recognize that atypical case patterns often present in the clinical setting, and that the evaluation process must be comprehensive enough to recognize key features that don't fit a particular known pattern. In retrospect this athlete's initial complaint of an adductor strain may have been the beginning of a stress fracture that displayed referred pain. Because femoral neck stress fractures are often not initially recognized and are frequently missed on x-ray, it is important to have diagnostic studies done to rule out fracture, or intra-articular hip pathology. If the diagnosis is delayed, and the athlete continues to participate with this injury, it may progress to a displaced fracture which could necessitate surgery and potentially result in a poorer outcome.

**Anterior Cervical Discectomy And Fusion With Previous History Of Posterior Foraminotomy: A Case Report**

Millspaugh R, DiCenso M, Geisler P:
Ithaca College, Ithaca, NY

**Background:** A 19 year old Division III male wrestler, with no prior history of cervical or shoulder pathology, presented with a gradual and insidious onset of pain, weakness and associated neurological signs and symptoms (s/s) in his left arm. Palpation failed to reveal cervical, shoulder or upper arm point tenderness. Limited shoulder AROM and significant forward head, rounded shoulders and thoracic kyphosis postures were noted. Pain and radicular symptoms increased with active and passive cervical ROM testing, and

diminished C1/C2, C5, C7 and T1 myotomes were found. C5 dermatome and deep tendon reflex were within normal limits, but C6 and C7 parasthesia was noted. Positive Allen's, Adson's & Roo's tests, negative Spurling's, and inability to perform a push up were also observed. **Differential Diagnosis:** Cervical disc protrusion, thoracic outlet syndrome, cervical spinal stenosis, vertebral instability. **Treatment:** Athlete was referred to the team physician; MRI (10/2006) revealed C6-C7 disc protrusion. Referral to an orthopedist and neurosurgeon followed. Initial treatment consisted of epidural injections, rest and traction for one month; producing little improvement. A posterior foraminotomy surgical relief was thus performed. Following six months of rehab, return to wrestling was granted (10/2007). Two months into season, he returned with left UE radicular s/s, increased neck and shoulder pain, C5-C7 point tenderness, weakened shoulder abduction, and a positive Spurling's test. A repeat MRI showed C6-C7 disc extrusion, and an Anterior Cervical Discectomy & Fusion (ACDF) was performed fusing C6-C7 (1/2008). Conservative treatment was not considered due to prior failure with this approach. Post-surgical rehabilitation focused on neck and shoulder ROM and strength; neural glides and gentle traction. Following 8 months of progressive rehabilitation, he was again cleared for collegiate wrestling. Following a two day tournament at the start of the 2008-2009 season, he returned with complaints of cervical neck pain and s/s in his left UE. Point tenderness of C4-C6 spinous processes and intervetebral spaces was present, and cervical ROM was limited and painful. Positive Spurling's and Valsalva maneuver's were noted, but UE neurological function was unremarkable. Re-evaluation one week post injury revealed no improvement, and a return of C4-C6 radicular symptoms. Subsequent physician evaluation revealed C4/C5 and C5/C6 disc protrusions (11/2008), disqualifying him from further wrestling participation. **Uniqueness:** Management of cervical disc pathology and associated radiculopathy can be successfully treated with a variety of methods for most athletes. In the current case, standard and conservative treatment methods were unsuccessful for a competitive wrestler, resulting in a minimally invasive posterior foraminotomy. Following extensive rehabilitation and a prudent return to play, re-occurring s/s required re-operation with the ACDF technique. Despite prior failure and a second reparative surgery, physicians approved return to full participation in which the athlete quickly developed a similar case pattern presentation. Given the high loads and risks wrestling places on the surgically repaired cervical spine, full return to play clearance was unusual. **Conclusions:** Conservative treatment for cervical disc pathology including anti-inflammatory medication, traction, epidural injections and physical therapy typically produces positive outcomes, and the literature suggests that surgical treatments are largely successful with only a small percentage requiring re-operation. Conservative treatment should first be ardently applied, and surgical intervention only considered if pain and radicular symptoms fail to resolve. This complex case reveals the need for further exploration on return to play guidelines and protocols for post-surgical cervical spine patients in high impact sports.

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**Ultrasound-Guided Plasma-Rich Protein Hamstring Injection In A Collegiate Football Athlete With Hamstring Tendinosis**

Lammert J, Asberry J, Doughty A, White L, Thornburg M, Tomchuk D, Rowlett M: Missouri Valley College, Marshall, MO, and Columbia Orthopaedic Group, Columbia, MO

**Background:** A 21 year old male football tight end with a history of recurrent left hamstring strains reports discomfort after completing a 40-yard sprint test during two-a-day practices. The discomfort was located in the left hamstring muscle belly. The athlete stated he fully complied with the football strength and conditioning summer program. Initial physical examination by the Athletic Training staff revealed a 4/5 MMT strength with left knee flexion and hip extension with no palpable defects noted. A grade I hamstring strain was diagnosed. An initial treatment protocol of ice, muscle stimulation, and rest was performed for 3 days. The Athletic Training staff began utilizing thermal modalities, NSAIDs, and implemented a strengthening and stretching program 3 days post-injury. The athletes' left hamstring extension was measured at 45º which was 15º lower than his contralateral side. The strengthening and stretching program was progressively increased over the subsequent week. The athlete began a running progression program 10 days post-injury when the strengthening program no longer induced substantial discomfort, the athlete had a 5/5 on all MMT's, and left hamstring extension increased to 50º. During the week-long running progression program, the athlete only complained of a slight dull pain in the middle of his left hamstring during high-speed sprinting and agility drills. This discomfort prevented him from achieving full speed and his confidence in running and cutting was diminished. At this time, the athlete was referred to an area sports medicine physician for further evaluation. **Differential Diagnosis:** Grade II or Grade III hamstring strain, femoral stress fracture, myositis ossificans, and avulsion fracture of the ischial tuberosity. **Treatment:** Upon physical examination and based on the athletes' history, the physician diagnosed the athlete with hamstring tendinosis and recommended a plasma-rich protein (PRP) injection guided by ultrasound to improve healing. The athlete gave consent and the procedure was successfully performed by the physician the same day. After the procedure, the initial treatment protocol consisted of complete rest and moist heat application for 5 days. An aggressive stretching program consisting of various hamstring stretches being held for 30 seconds each and a running progression program began under the supervision of the Athletic Training staff. A strengthening program was not performed because the athlete had a 5/5 MMT on both hamstrings and only reported hamstring complaints during high-speed sprinting and agility drills prior to PRP treatment. This program was performed for one week. The athletes' left hamstring extension improved to 60º. The athlete followed-up with the physician after the running progression program and demonstrated no hamstring tenderness, 5/5 MMT hamstring strength, and no ROM deficits. The physician allowed the athlete to progress to full participation in all football activities as tolerated. The athlete subsequently returned to full football participation and a hamstring strength and conditioning maintenance program was created and implemented by the Athletic Training staff. The athlete successfully started and competed in all 9 remaining football games after being cleared by the physician without reporting hamstring discomfort. **Uniqueness:** PRP injections are becoming common procedures designed to improve healing in muscle, tendon, ligament, and bone injuries. The use of PRP on this athlete, demonstrates the potential for this treatment being utilized to assist athletes return to full participation after hamstring tendinosis. A case report on PRP injections for hamstring tendinosis and a possible rehabilitation and return-to-participation protocol has not been presented in Athletic Training literature. **Conclusions:** Athletes with hamstring tendinosis may benefit from PRP treatment. Although this athlete tolerated this treatment well and progressed rapidly, Athletic Trainers should attempt a conservative treatment and rehabilitation program before a PRP treatment is performed.

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**The Use Of Autologous Conditioned Plasma To Treat Chronic Patella Tendinitis: A Case Analysis**

Estes MA, Felton SD, Whetstone J, Schiegner N, Guerra JJ: Florida Gulf Coast University, Fort Myers, FL

**Background:** This report details the treatment of a 22 year-old male collegiate baseball pitcher suffering from chronic patella tendinitis. The athlete had been receiving conservative treatment throughout the fall season until the semester break with limited success. Athlete went hiking over the holiday break and felt a "pop" in his knee and returned for the start of the spring semester and was evaluated by the Certified Athletic Trainer (ATC). The physical exam revealed localized swelling, pain along the anteriolateral joint line, with a positive Mc Murray's Test. Athlete was referred to the Team Physician for follow-up. **Differential Diagnosis:** Hamstring Strain, Illiotibial Band Strain, Meniscus Tear, Anterior Cruciate Ligament (ACL) Sprain, Patella Tendinitis, Patella Tendon Strain **Treatment:** At the Team Physician examination, the effusion had resolved and athlete only presented with anteriolateral joint pain. An MRI was scheduled which revealed no mensical tear and a moderate grade partial intrasubstance tear of the patella tendon at its origin. Once the team physician reviewed the results it was decided to proceed with an Autologous Conditioned Plasma (ACP) procedure, also known as Platelet Rich Plasma (PRP) procedure. The ACP procedure involves drawing a small amount of the patient's own blood and the liquid being centrifuged for five minutes. This causes separation of the red and white blood cells and leaves a solution of concentrated platelets. This concentration contains from 2 to 5 times the number of platelets and 2 to 25 times the amount of various growth factors that the same volume of the patient's whole blood contains. The PRP concentration was injected at the site of pain, after a local anesthetic injection consisting of 3CC of Bupivacaine with epinephrine. The PRP concentration was injected utilizing a peppering technique which consists of five penetrations at the site of injury. Following the injection, the athlete was ordered by the Team Physician to refrain from sport participation for seven days but could continue with non-aggressive rehabilitation, as outlined in the protocol with ACP injections. The athlete's rehabilitation plan consisted of straight leg raises, ¼ wall squats, quad setting exercises, stretching exercises, and low intensity stationary bike workouts. Prior to the exercise he would receive thermal therapy consisting of hydrocollator pack and 3MHz continuous ultrasound at 1.2W/cm2 for 10 minutes. After completing the exercises he would receive interferential electric stimulation and cryotherapy. Ten days following the injection, the athlete resumed modified activity which consisted of light throwing on flat ground. Fifteen days post injection; he progressed to throwing from the mound. He continued the progressive rehabilitation an additional 1 ½ weeks until he achieved full strength and released to full activity. **Uniqueness:** Patella tendinitis is an extremely common ailment treated by ATCs most often resolved through conservative management and participation modification; however, this condition can be disabling when the condition does not respond to conservative means and is associated with a partial intrasubstance tear. Therefore, as highlighted in the case, the use of Platelet Rich Plasma injections was a beneficial alternative treatment for the athlete suffering from this condition. It allowed the athlete a full recovery after dealing with the condition for over six months. **Conclusions:** This cases highlights the successful treatment of an athlete suffering from chronic patella tendinitis with a relatively new treatment approved by the FDA, Autologous Conditioned Plasma. The athlete has made a full recovery and no longer experiences pain or swelling in the knee region. This case provides an example of a successful outcome in collegiate athletics with the new treatment procedure and should be considered as a treatment option for the Sports Medicine Team when treating patients for chronic tendon pathologies.

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**West Nile Encephalitis In A Collegiate Softball Pitcher**

Allerton LA, Sterner RL: Rowan University, Glassboro, NJ

**Background:** A twenty year old female Division III Collegiate softball pitcher, attending a New Jersey institution, reported to the athletic training room that she was diagnosed with West Nile Disease the previous summer. This transfer student-athlete indicated that following a tournament in Florida she began complaining of lethargy, fever, headaches, and general body aches. An initial physician follow-up, in New Jersey, indicated she was diagnosed with mononucleosis. A few weeks later she went to her physician again because her symptoms continued to persist and she developed Bell's Palsy to the right side of her face. She was admitted to the hospital and treated for meningitis. Again symptoms continued to persist which lead to a cultured spinal tap being completed. This diagnostic test revealed that this athlete had contracted West Nile Encephalitis which was thought to occur as a result of a mosquito bite that transpired during the Florida softball tournament. The athlete continues to have complications as a result of this pathology which include: anemia, seizures during sleeping, night sweats, neuropathy within her left arm and severe headaches with activity. During a preseason practice, she complained of an extreme headache, diplopia and disorientation, with no history of head trauma, that were so intense she was referred to the local emergency room. Here she was given Benedryl, morphine and steroids to treat the acute symptoms and then released. She has since seen an infectious disease specialist and neurologist to manage her complications resulting from this disease. **Differential Diagnosis:** West Nile Meningitis, West Nile Poliomyelitis, Mononucleuosis, Lyme's Disease, Tuberculosis. **Treatment:** The athlete is currently taking a plethora of medications to treat the symptoms of this pathology. These medications include: Melotonin, Percocet, Floricet, Immitrex, Klonopin, Rivotril, and Topamax. She returned to activity one week after seeing the infectious disease specialist with the only limitation being rest if symptoms increased during activity. **Uniqueness:** This case is exceptional because the West Nile virus is rare within the athletic population in the Northeast. Several incorrect diagnoses were reported possibly because of the infrequency for which it is seen within the active population. **Conclusion:** West Nile Encephalitis is uncommon and with this so is the literature. There is almost no material discussing this disease in the athletic population and very little, if any, material on the long term effects and secondary complications of this illness.

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**Management Of An Open Displaced Tibio-Fibular Fracture In A 20-Year-Old Male Collegiate Soccer Player: A Case Report**

Shotwell C, Shotwell R, Vanic K: East Stroudsburg University, East Stroudsburg, PA, and King's College, Wilkes-Barre, PA

**Background:** A 20-year-old healthy male collegiate soccer player was slide tackled by an opponent during an away conference competition. The Certified Athletic Trainer's on-field evaluation concluded an open displaced fracture of the right lower leg. The wound was dressed with sterile gauze and immobilized by a vacuum splint and the athlete was referred to the Emergency Room via ambulance. Upon arrival at the hospital, the athlete remained in the vacuum splint without consultation for approximately 3.5 hours. **Differential Diagnosis:** Gustilo-

Anderson Type III A Fracture, Transverse Fracture, Open Tibial Fracture. **Treatment:** X-Rays were obtained, and a full evaluation both inside and outside of the operating room revealed two traumatic wounds in the posterior lateral aspect of the lower leg, resulting in a Gustilo-Anderson Type III A Open Fracture at the level of the junction between the middle and distal third of the tibia and fibula. The orthopedic surgeon's plan was to irrigate and debride the wound and place an intramedullary rod through the tibia. Over the course of 10 days post-op the athlete developed many infections resulting in a total of five surgeries to irrigate and debride the wound. During his sixth surgery ostomyelitis was noted, and continued to develop despite the surgeon's best efforts to control the infection. Eleven weeks post initial injury, x-rays indicated nonunion of the tibial fracture, as well as an extension of the osteomyelitis 6-7 cm proximally from the fracture site. The orthopedic surgeon decided that the patient would undergo a segmental tibial resection and an Ilizarov bone transfer. He also informed the patient of the seriousness of the infection, and that this surgery was the last option before amputation would be necessary. Over the next two weeks the procedure was performed and the patient was placed in a 6-ring Ilizarov frame. Approximately one month post bone transfer, x-rays revealed that the proximal osteotomy was widened 23 mm indicating excellent regeneration, as well as no evidence of infection. The athlete underwent rehabilitation with the University's Athletic Training Staff over a 15-month time frame. The rehabilitation included pain control, range of motion and flexibility exercises of the foot ankle and lower leg, strengthening of the entire lower quarter, proprioception and functional exercises, as well as exercises focusing on cardiovascular endurance. The athlete developed contractures in his first and second toes due to the Ilizarov frame. Once the frame was removed his first and second metatarsals were treated with fusion and tenotomy which corrected his adaptive hammertoe deformity, The athlete was able to return to competitive play approximately 23 months post-injury with only discomfort in his great toe. **Uniqueness:** Due to the number of infections that were sustained, possibly because of delayed management, the athlete had to undergo 12 surgeries for an open tibio-fibular fracture. Had the athlete been older and his growth plates been closed the Ilizarov bone transfer would have not been successful. This would have resulted in the athlete undergoing amputation of his right lower limb. **Conclusions:** It is essential for athletic trainers to have good knowledge of the on- and off-field management and classifications of open tibial fractures, as well as the expedient referral and management of these injuries. Common beliefs state that the classification of the open fracture can help define the antibiotic and management treatment. Also, early management of these injuries may help reduce the chance of infection.

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**Evidence Based Management Of Unilateral Patellofemoral Pain Syndrome In A Division I Female Basketball Player**

Baum MJ, Thoens AL, Vesci BJ:
Boston University, Boston, MA

**Background:** We present the case of a 19 year old female division I basketball player (body mass=88kg, height=180cm) who presented in September with non-specific right anterior knee pain that began in June. She had been playing basketball, and completing workouts at full function throughout the summer. Pain had increased and she was unable to complete practices and workouts due to pain. She complained of pain during the initial degrees of flexion. Patella alta, lateral tracking, and patellar tilt were noted. No apparent leg length discrepancy was noted. A true leg length discrepancy was found with the right leg approximately 3cm longer than the left. No misalignment of hips noted. Inspection of gait revealed increased pronation on the right foot with 13mm of navicular drop. Increased Q-angle relative to the left leg is present (~20°) with increased hip internal rotation, and femoral anteversion. Tibial varum measured as 7° in the right leg. **Differential Diagnosis:** Patellofemoral pain syndrome (PFPS), patellar tendonopathy, femoral chondromalacia, meniscal tear. **Treatment:** The patient was initially given a Don Joy "Tru-Pull" patella brace by a team physician with no relief of symptoms. Rehabilitation began 5 weeks prior to the season to address the biomechanical dysfunction described by Wilk, and Souza and Powers, 2009. Rehabilitation consisting of quadriceps and hip abductor strengthening, and neuromuscular control was similar to the protocol described by Boling et al, 2006. Exercises were performed 3 times per week and included 4-way hip, clams, gluteus medius hikes, and a variety of proprioceptive exercises. Our patient fit the clinical prediction rule for McConnell taping described by Lesher et al, 2006. McConnell taping was applied for practices and workouts with a medial glide. **Uniqueness:** Each case of PFPS can benefit from a systematic approach to classification and management. A wide body of research is available regarding the classification and treatment of PFPS. However, outside of these study samples, there are few clinical case reports demonstrating the use of this classification system. This also holds true for the clinical prediction rule for McConnell taping. A large body of research supports its use, but lacks clinical case reports outside of the study sample. Our case demonstrates that clinicians who are relatively inexperienced with the PFPS classification system and the CPR for McConnell taping can easily use and apply the literature with positive results. Clinicians without an expertise in these areas can easily manage and treat athletes who present with PFPS. **Conclusions:** By the beginning of the season our patient was able to complete practices and workouts, and compete in games with full function. Prior to intervention, pain on the VAS scale was assessed as 6/10. After five weeks of rehabilitation pain was assessed at 0/10. A maintenance program was started to sustain gains made strengthening and neuromuscular control. Pain was assessed again 4 weeks later and recorded as 0/10.PFPS is one of the most common conditions affecting the lower limb. Despite the prevalence of this condition, the success rate of interventions can vary greatly. Furthermore, there are few examples of an evidence-based approach to the management of this common condition. This is one of the few clinical case studies to address the application of the existing classification system, and future research is needed to investigate these benefits. Human based randomized control trials should be conducted to further support the use of the PFPS classification.

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**Idiopathic Foot And Ankle Pain In A Division I Collegiate Softball Athlete**

Burke CM: Northern Illinois University, DeKalb, IL

**Background:** On September 29, 2009, a 19 year old female, Division I softball student-athlete reported to the athletic training room with medial ankle pain. Her pain began just below the distal medial malleolus and extended into the medial longitudinal arch of her right foot. She had no history of trauma to the ankle and no signs of edema or ecchymosis. She did not complain of any point tenderness over any bony structures. However, she did present with point tenderness over the distal portion of the deltoid ligament and the proximal medial longitudinal arch. The athlete had no complaint of paresthesia in the right ankle or foot, and a neurological exam was equal bilaterally. The athlete had full ankle and foot range of motion and appeared to have relatively normal gait with a mild rear-foot valgus. Her foot and ankle also demonstrated full ligamentous stability. **Differential Diagnosis:** Deltoid ligament pathology, Medial malleolar avulsion facture, Plantar fascitis, Posterior Tibialis

strain, Flexor retinaculum pathology, Medial ankle space occupying lesion. **Treatment:** Due to the signs and symptoms the athlete presented with upon the initial evaluation, the injury was treated as a deltoid ligament sprain with medial longitudinal arch involvement. Initially, the athlete was treated with anti-inflammatory and pain control modalities and taped for modified activities. Also, the athlete was fitted with heat moldable orthotics to be worn at all times. After two weeks, the athlete was complaining of increased pain and some paresthesia in the medial ankle, and extending into the plantar surface of the foot across the first three metatarsals. The athlete was then referred to the team physician, who concurred with the assessment of a medial ankle sprain and recommended the athlete be placed, weight bearing, in a cam walker and restricted from all team activities for four weeks. During this time the athlete had no relief of symptoms. Physician ordered radiographs were taken, and revealed no abnormalities in the foot or ankle. Magnetic resonance images (MRI) were taken that showed no damage to any of the soft tissue structures of the foot or ankle. This athlete was then referred to a foot and ankle specialist for further evaluation. An Electromyography (EMG) nerve conduction test was ordered, which showed that the tibial nerve was compressed within the tarsal tunnel. As a result the athlete was diagnosed with tarsal tunnel syndrome, and a steroidal anti-inflammatory injection was given into the tarsal tunnel in an attempt to decrease the pressure on the tibial nerve. This injection gave the athlete no relief of pain or symptoms. The physician recommended a surgical procedure called a tarsal tunnel release including a release of the plantar fascia. This procedure calls for a total release of the tarsal tunnel, thereby decreasing pressure on the tibial nerve. The athlete underwent this procedure on November 19, 2009. **Uniqueness:** Tarsal Tunnel Syndrome is very unusual in the collegiate aged and athletic populations. Primarily, this syndrome is found in the middle aged (40-50 years) population and overweight individuals. Tarsal tunnel, in an athletic population, typically presents after a traumatic event to the medial ankle, and is very rare that this issue presents idiopathically, especially in this subgroup. **Conclusion:** The symptoms of tarsal tunnel syndrome can vary significantly from patient to patient. Additionally, it is very uncommon to find this type of problem within the traditional collegiate age group or an athletic population. Although the syndrome is commonly associated with traumatic injuries or a rear-foot valgus, this athlete did not have any significant predisposing factors. Therefore, more research is needed to determine other intrinsic and extrinsic factors that could potentially contribute to this issue.

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**Platelet Rich Plasma Injection For A Chronic Hamstring Injury In A Division I Track Athlete**

Vesci BJ, Gibb ES, Pecci MA; Boston University, Boston MA

**Background:** This case presents a 19 year old male Division I track athlete with a mass of 74 kg and height of 173 cm. The patient has a history of left hamstring tightness and pain extending back to fall of 2008. The patient experienced a popping sensation during sprinting in his left proximal hamstring in January of 2009. The patient has no other history of lower extremity injury. Currently, this patient presents following failed conservative treatment of a left proximal hamstring strain. The patient has no co-morbidities associated with musculoskeletal injury. **Differential Diagnosis:** Avulsion fracture, Hamstring strain, femoral stress fracture, femoral tumor, sciatic nerve entrapment. **Treatment:** The patient was treated conservatively with progressive resistive exercises and core stabilization training through both the athletic training staff and a physical therapist. The patient's strength improved to equal bilaterally to manual muscle testing; however, he continued to experience symptoms each time he attempted a slow progression back to running. The patient received a corticosteroid injection in April of 2009, but did not experience relief. An MRI was ordered that confirmed the diagnosis of a strain at the proximal musculotendinous junction of the semitendinosus Following the exhaustion of conservative methods of treatment, the patient received a platelet rich plasma injection to the proximal musculotendinous junction of the semitendinosus of his left hamstring on September 25, 2009. He experienced increased inflammation and pain in the week following the injection, which was expected. Once acute inflammation had subsided, the patient continued rehabilitation exercises with the athletic training staff and was progressed slowly back to running. By November 2009, the patient was able to return to full training intensities. **Uniqueness:** It is unusual for symptoms from a muscle strain to linger for close to 12 months post injury, especially in conjunction with rehabilitation and strengthening. Standard of treatment for a hamstring injury usually includes strengthening, balance and flexibility exercise, and sometimes the use of oral anti-inflammatory medications. When these conservative methods are not completely effective in alleviating pain, it is not uncommon for a patient to receive a corticosteroid injection. Platelet rich plasma injection is a relatively new treatment option for orthopedic injuries, and would not be considered part of the rehabilitation program for every patient with a hamstring strain. **Conclusion:** When conventional, evidence-based, methods fail in the management of musculoskeletal injuries, it is imperative to explore more aggressive treatment approaches that are not as well explored in the literature. Platelet rich plasma injections are being utilized more frequently in the treatment of musculoskeletal pathology; however, guidelines have not been established for initiation and frequency of these injections. Anecdotal evidence suggests that platelet rich plasma therapy is improving patient outcomes.

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**Blunt Abdominal Trauma In A Collegiate Football Player**

Gatti JM, Anish EJ, Woods S: Duquesne University, Pittsburgh, PA, and University of Pittsburgh Medical Center, Pittsburgh, PA

**Background:** A collegiate wide receiver was struck in the abdomen by an opposing player's helmet as he was attempting to catch a pass. The athlete fell to the ground and was unable to return to the huddle. On-field evaluation by the athletic training staff revealed sharp pain over the right upper quadrant (RUQ) of the abdomen as well as pain over the lower right chest. The athlete rated the pain as 6/10 during the on-field evaluation. The athlete's on-field exam was unremarkable and the findings did not contraindicate movement to the sideline for further evaluation. A thorough medical history revealed that our athlete was an otherwise healthy 19 year old male (weight= 86.6kg, height= 184cm). Sideline examination at approximately 5 minutes post-injury revealed an increase in pain to 9/10, no signs of respiratory distress, tenderness to palpation over the RUQ and right lower chest, abdominal guarding/rigidity, and rebound tenderness. After consulting with a team physician, the decision was made to transport the athlete to the local hospital's emergency department (ED). **Differential Diagnosis:** Rib fracture, abdominal wall contusion, liver laceration, pancreatic laceration, bowel rupture, ureteral laceration, kidney laceration/ contusion, pneumothorax, pulmonary contusion. **Treatment:** Upon arrival to the ED, the athlete's vital signs were as follows: BP-105/65, RR-20 non-labored, HR-105 bpm, and oral temperature-36.3°C. ED physicians immediately ordered labs revealing elevated liver enzymes. Aspartate amino-transferase (AST reference range < 40U/L) and alanine aminotransferase (ALT reference range < 40U/L) are commonly used to measure liver injury/disease. Our athlete's

blood AST and ALT were 452 U/L and 490 U/L respectively. At that time, the athlete was hemodynamically stable and was taken for CT scans of the chest, abdomen, and pelvis which revealed a liver laceration with an 8cm x 6cm liver hematoma. ED staff decided to manage him conservatively and admit him for observation. Serial labs and CT revealed that the athlete was improving and he was subsequently discharged from the hospital on day number four. A final diagnosis of a Grade II intraparenchymal liver laceration with hematoma was made. The athlete was seen by the team physician 9 days post-injury. The decision was made to limit all physical activity pending follow-up labs and CT. At 4.5 weeks post-injury AST and ALT returned to normal, but CT still showed a 6.5cm x 5.8cm liver hematoma. After consulting with various outside sources the team physician decided to continue to limit the athlete's physical activity to light, non-impact, aerobic training until the hematoma had resolved. A repeat CT approximately 10 weeks post-injury still showed a 4cm x 5.3cm liver hematoma. The clinical outcome of this case is still pending as complete liver hematoma resolution has yet to be achieved. **Uniqueness:** Abdominal injuries are rare in sports, but when they occur they can be life-threatening. Although less common than splenic injuries, traumatic injuries to the liver can occur during athletic participation as a result of either a direct blow or deceleration mechanism. Evidence-based guidelines for return-to-play (RTP) following a liver injury are lacking. However, most recommendations suggest that both functional and anatomic healing be documented before the athlete returns to play. **Conclusions:** This case illustrates a rare type of sports-related traumatic injury. Having a high index of suspicion for a hepatic injury in the setting of blunt abdominal trauma is critical to achieving a good clinical outcome. Since most RTP guidelines following a liver injury include both functional and anatomic healing, this case is valuable in demonstrating how quickly liver transaminases may return to normal post-injury and the extended time that it may take for a liver hematoma to resolve.

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**Respiratory Distress In A Collegiate Field Hockey Player**

Johnson W, White T, Mead J, Straub SJ:
Quinnipiac University, Hamden, CT

**Background:** During fall fitness testing, an athlete stopped running and was observed to be struggling to catch her breath as her body appeared to go into jerky spasms. The medical staff approached the athlete, anticipating an incidence of exercise induced asthma (EIA) which had dogged her since childhood; she suffered multiple EIA attacks earlier in the season The athlete was struggling to breathe, taking short shallow breaths and there were no sounds associated with a typical asthma attack such as wheezing or coughing. The athlete was in obvious distress. She was unable to catch her breath even with the aid of her emergency Albuterol inhaler. The athlete was transported to health services where she received an Albuterol nebulizer treatment as well as an epinephrine injection, both of which were also ineffective. Since symptoms persisted ten minutes after treatment, she was transferred to the local hospital via ambulance. She was admitted into the intensive care unit and treated with an Albuterol nebulizer, oxygen and multiple corticosteroid injections. Ultimately she was intubated and connected to a BPAP machine using helium as a mode to increase the airflow into the lungs. **Differential Diagnosis:** Exercise induced asthma, upper respiratory infection, anaphylactic shock, vocal cord dysfunction **Treatment:** Following intubation the athlete's respiratory difficulties subsided. A diagnostic laryngoscopy was performed to evaluate her vocal cord function during respiration. The laryngoscopy revealed abnormal adduction of the vocal folds during respiration thus leading to the diagnosis of vocal cord dysfunction. Once she regained full, natural respiration the athlete met with a speech therapist who instructed her in relaxation techniques, diaphragmatic breathing and relaxed throat posture. Diaphragmatic breathing is a technique teaching the athlete to breathe using her diaphragm to expand the stomach, creating deeper breaths in turn decreasing anxiety, it is also known as belly breathing. Relaxed throat posture was used to help relax the athlete's vocal folds. While in the hospital the athlete had recurrent episodes of respiratory distress but was able to use the relaxation techniques to regain control of her respiration. After four days she was released from the hospital and instructed to continue practicing relaxation techniques with the certified athletic trainer. The team physician cleared her to return to play. Two weeks after discharge from the hospital the athlete had a severe exacerbation of signs and symptoms following a game lasting nearly 45 minutes, but was successful in regaining control of her respiration through relaxation techniques learned during her hospital stay. She was able to complete the rest of the season without any significant return of respiratory distress. **Uniqueness:** Respiratory distress in athletes is typically attributed to an asthmatic condition. Most athletes respond to treatments of inhalants or corticosteroids. When these treatments are unsuccessful one must consider other diagnosis. VCD is a rare condition but has become more common since the first reports in 1986. VCD is commonly misdiagnosed due to the signs and symptoms that are shared with asthma. Unlike EIA the patient cannot recreate signs and symptoms, thus making it difficult to diagnose until there is an acute onset. Once the patient is diagnosed and taught relaxation techniques many are able to reduce severity of a sudden onset of VCD. **Conclusion:** Misdiagnosis of VCD (due to common signs and symptoms with EIA) can lead to an emergency. The most important symptom to observe is where the stridor is heard and where the obstruction is experienced. Stridor emanating from the neck is indicative of VCD. The diagnosis of VCD can only be made during an emergency and acute onset due to the inability to recreate symptoms. Understanding the different signs and symptoms of VCD and EIA is key to properly diagnose an athlete.

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**Abdominal Injury In A Male Division I Ice Hockey Player**

Bremmer B, Kaplan R, Norkus S:
Quinnipiac University, Hamden, CT,
and Yale University, New Haven, CT

**Background**: A 21 y/o male ice hockey player was participating in a regular season game and while returning to the bench for a shift change, was blind-sided on the left side by an opposing player. The athlete left the ice under his own power but immediately reported severe pain in his left upper quadrant. The athlete reported no LOC and had no complaints of dizziness, disorientation, or memory loss; he complained of mild facial and neck pain which improved quickly. Upon evaluation, the athlete appeared pale and had superficial abrasions on the left side of his face. Initial blood pressure in supine was 104/60 which increased to between 110-118/ 76-82 over the next 15 minutes, while pulse was 68 bpm which remained between 60-70 bpm during the serial checks. Upon abdominal evaluation there was no obvious deformity or rigidity. Bowel sounds were quiet but present and abdominal tenderness was limited to the left upper quadrant. Upon percussion the spleen seemed to be enlarged projecting to the costal margin. **Differential Diagnosis**: Internal organ contusion; internal organ laceration; rib fracture; rib contusion. **Treatment**: The athlete was transported via ambulance to the local hospital. A precautionary IV was started during transport and vitals remained WNL. A CT scan of the abdominal region was ordered and revealed splenic enlargement and bleeding causing free fluid in the abdominal cavity as well as enlarged lymph nodes. Enlarged lymph nodes and spleen were suggestive of an infectious response, which was determined through

blood work to be a mononucleosis infection. The final diagnosis was a grade III splenic laceration resulting in a 25% devascularization of the splenic parenchyma, secondary to infectious mononucleosis. An immediate splenic artery angiogram and splenic artery embolization were ordered. The surgeon carried out the embolization through the right common femoral artery with the puncture site in the right groin. The athlete remained in post surgical ICU for 48 hours before being moved to a general care floor for another two days. Discharge orders were given on the fourth day post operative to release the athlete to the university health services where he remained for one day. He was released with orders to follow up at the trauma clinic in two weeks and was instructed to avoid contact sports. At 2 weeks s/p the athlete was instructed to refrain from physical activity until 4 weeks had passed from onset of symptoms and blood work indicated that the mononucleosis infection had subsided. **Uniqueness**: Splenic injuries in ice hockey are uncommon and are primarily seen in automobile accidents, equestrian, or aerial sports. Following the injury, the athlete did not present with weak pulse, nausea, dizziness, abdominal rigidity, Kehr's sign or other signs of abdominal trauma. Also, although the athlete was suffering from a case of mononucleosis severe enough to cause splenic and lymph node enlargement, he presented with no signs or symptoms prior to the injury. Mononucleosis is generally self limiting and individuals are typically unable to withstand intense physical exertion due to extreme fatigue, fever, weakness, and other symptoms. This athlete, however, had no complaints or impaired performance prior to the injury. **Conclusion**: The undiagnosed mononucleosis infection was determined to be the cause of the enlarged spleen predisposing the athlete to rupture. Following the injury, appropriate evaluation and diagnosis led to a quick and successful treatment. The athlete slowly returned to activity and was able to return to non contact skating and biking 4 weeks s/p. Approximately 7 months s/p the athlete has been medically cleared to return to hockey and has no complaints of lingering symptoms.

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**Metatarsalphalangeal Pain In Football Player**

Dhuy E, Pike T, Wilson: University of Kentucky Orthopaedic Surgery and Sports Medicine, Lexington, KY

**Background:** A 27 year old male arena football player reported to the Athletic Trainer two week after collision with padded wall during competition. Chief complaint was plantar pain to the metatarsalphalangeal joint of the left hallux. The mechanism of injury was described as attempted plantar flexion with forced hyperextension of toes against the wall. Prior history includes several instances of bilateral turf toe dating several years during collegiate play. Pain was described as sharp during running and weight bearing activities. Slight bruising with minimal swelling was noted. Active flexion and passive extension of first toe caused greatest pain during evaluation. Initial treatment included ridge inserts, cryotherapy, rest from running activities, turf toe tape into slight plantar flexion and Ibuprofen. Two weeks later athlete attempted to return to activity but was unable to complete practice due to pain. Athlete was then sent to the physician for further evaluation and x-rays. **Differential Diagnosis:** Contusion, sesamoiditis, hallux rigidus, strain of the flexor hallucis longus and brevis, sesamoid fracture. **Treatment:** Anteroposterior, lateral, and oblique radiographs were taken 4 weeks post initial injury of the first ray and showed a transverse fracture of the lateral sesamoid of the left great toe. The athlete was placed in a walking boot for 5 weeks and placed on a non-weight bearing cardiovascular program of stationary biking and swimming. Athlete was progressively taken out of boot and began weight bearing activities as tolerated with a metatarsal pad. 7 weeks after diagnosis repeat radiographs were taken and showed smooth ossification of the fracture site. No tenderness was evident and full ROM of metatarsal-phalangeal joint was noted. Athlete returned to practice with minimal soreness after activity and was able to complete the season without further complication. **Uniqueness:** Chronic stress fractures of the sesamoid bone are more frequent due to the high weight bearing forces translated during the toe off phase of explosive activity Due to the larger size and location, the medial sesamoid bone is more commonly injury then the lateral sesamoid bone. Lastly, the previous history of turf toe may have been a predisposing factor. **Conclusions:** The location of pain over the plantar aspect of the first ray, force hyperextension mechanism of injury and the immediate pain after a few weeks of rest were all signs leading to a diagnosis of a sesamoid fracture. Once a fracture is suspected a simple radiograph is important in the final diagnosis.

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**Knee Injury In An Adolescent Athlete**

Stafford KM, Jagger J, Mair S, Mattacola CG: University of Kentucky, Lexington, KY

**Background:** A 13 year old male middle school football player presented with medial left knee pain after a tackle that forced his upper body into rotation while his foot was planted. He had no previous history of lower extremity injury. The athlete reported a "pop" and diffuse pain over the entire medial aspect of his knee. He was able to bear weight with pain. He had point tenderness along the MCL, but no tenderness along the medial joint line or surrounding structures. He lacked 20 of extension due to pain. The Lachman's Test was positive for pain and a soft end-feel. The athletic trainer noted negative anterior and posterior drawer tests and pain with a valgus stress test, but no laxity. He was given ice and crutches and referred to the sports medicine physician. **Differential Diagnosis:** ACL sprain, MCL sprain, distal femoral or proximal tibial epiphyseal injury, meniscus tear, and hamstring tendon strain. **Treatment:** The athlete presented to the physician one day post-injury with knee effusion, tenderness over the MCL, and a knee extension deficit of 20°. He had pain with a valgus stress test and remained negative for medial joint line tenderness. The physician noted a negative anterior drawer test and a positive Lachman's test. An MRI was ordered to confirm a clinically diagnosed Grade II MCL sprain and probable ACL disruption. MRI findings showed no injury to the MCL or ACL, but revealed a double PCL sign consistent with a bucket handle tear of the medial meniscus. Final diagnosis was an acute bucket handle tear of the posterior horn of the medial meniscus. The athlete was immobilized at 20°of flexion, given instructions for treating the pain, and scheduled for surgery one week after the initial injury. A knee arthroscopy with inside out medial meniscus repair with fibrin clot augmentation was performed without complications. He participated in physical therapy following the surgery and was released for physical activity 4 months post-surgery. He successfully completed his first high school football season in fall 2009. **Uniqueness:** The athlete's clinical evaluation revealed a mechanism of injury consistent with an ACL injury. He also had tenderness on the MCL, but lacked tenderness on the medial joint line. According to the literature medial joint line tenderness for a medial meniscus tear has a sensitivity of 92%. The athletic trainer noted a positive Lachman's test with a soft end feel and pain. The literature has shown that the Lachman's test has a specificity of 91% for ACL sprain. His evaluation revealed pain with a valgus stress test, as well as pain and a 20 knee extension

deficit. His clinical presentation was inconsistent with MRI findings. Meniscal tears in adolescents are not as common as tears in adults; although bucket-handle tears are more common in adolescents than adults. **Conclusion:** This case presents a bucket handle meniscus tear in an adolescent male that had a unique clinical presentation. The primary clinical observation of a bucket handle tear is an extension deficit. The Lachman test for ACL tears may result in false positives in the presence of a bucket handle tear due to the influence of the displaced meniscus fragment in the joint space. This is also a case that reveals a false negative for meniscus tears using medial joint line tenderness. Clinicians should be aware of the subtle presentation of bucket handle meniscus tears in an adolescent population.

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**Acute Right Lower Abdominal Pain In Division I College Football Player**

Amponsah GP, Naohisa I, Jagger JA, Mattacola CG: University of Kentucky, Lexington, KY

**Background:** A 20 year old male football player complaining of right lower abdominal pain. He had a history of a hip flexor muscle strain two weeks prior to this incident. During the initial incident the athlete complained of acute onset of tightness and pain over the hip flexor muscle during practice. He was able to finish practice. He was evaluated after practice by an AT. His active manual muscle test (MMT) for hip flexion was 3 out of 5 for both the seated and supine positions. He was able to actively flex his thigh to 90 deg but lacked full range of motion. There was no deformity or significant swelling. He complained of general pain that radiated from his illiopsoas tendon proximally to the ramus of the pubis. He then received treatment in the athletic training room which consisted of cryotherapy, inferential, Hivamat, and ultrasound along with anti-inflammatory medication. He returned to practice 2 days after the initial injury on a limited basis. A Hip flexor spica protective wrap was applied during practice. He gradually increased his activity level progressing from running in a Swimex to straight ahead running until he was full participation. Two weeks after the initial injury he started feeling severe pain the right lower abdomen. He was unable to finish practice. He was seen by the team physician on same day. He presented with general tenderness around McBurney's point, and the pain was reproducible with significant guarding. **Differential Diagnosis:** Hip flexor strain, rectus femoris avulsion fracture, appendicitis, and sports hernia. **Treatment:** He was driven to the university student health facility to rule out acute appendicitis. At student health, he was tested for complete blood cell count. He presented with slightly decreased number of white blood cells. At this time, the physician requested C.T. scan. The C.T. scan was ordered immediately and it indicated a large hematoma of the illiopsoas muscle and a healthy appendix. The hematoma was located behind the appendix. The athlete was restricted to bed rest for 3 days. The goal of the bed rest was to prevent any additional trauma and potential swelling into the retroperitoneal space. After 3 days of rest he returned for rehabilitation. He gradually increased his activity level progressing from strengthening exercise; straight leg raises and 4 way hip to more functional exercises which included stationary biking, active range of motion and aqua-therapy in a Swimex, to straight ahead running. Nine days after the CT scan, he stated that symptoms were significantly improved, thus he was instructed to increase the intensity of the rehabilitation as tolerated. He was allowed full participation 12 days post CT. **Uniqueness:** The illiopsoas strain is a common injury for football players; however it is rare to see a significant tear located behind the appendix. The majority of reported case studies of hematoma to the illiopsoas tendon are reported in individuals with hemophila. This patient has no known blood disorders and was not taking aspirin or any anticoagulants at the time of the incident. The location of this injury resulted in false positive clinical signs for acute appendicitis, including tenderness around McBurney's point and a decreased number of white blood cells. **Conclusions:** Illiopsoas strain resulting in hematoma may present symptoms similar to those consistent with acute appendicitis. Therefore, recognition of other structures that present with signs/symptoms mimicking an appendicitis is useful clinical information. Clinicians should be cognizant that an illiopsoas strain or re-injury may also develop significant complication such as femoral nerve compression.

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**Knee Injury In A Middle School Athlete**

Hosey RΓ, Lounsberry NL, McKeon PO: University of Kentucky, Lexington, KY

**Background:** A 13yo male football player was tackled from behind during a game on 9/10/09. On the field, he reported landing on his right knee and indicated pain on the anterolateral and anteromedial aspects of his knee. He was unable to bear weight and held his knee in approximately 30° of flexion. The athlete reported a previous history of Osgood-Schlatter disease in his right knee. Sideline evaluation revealed no edema, effusion, or ecchymosis around the knee. He was tender to palpation on the proximal-medial tibia. He reported mild tenderness on the tibial tuberosity, and diffuse tenderness over the anterolateral and anteromedial aspects of the knee. Active range of motion (ROM) was limited to 90° of flexion and he was unable to perform any active extension secondary to pain. Passive ROM was limited to 90° of flexion and 5° of extension. Special tests including Lachman's, anterior drawer, and Slocum drawer tests were all negative for laxity, but positive for pain. Posterior drawer and varus/valgus tests were negative. He was given ice and instructed to use crutches as needed. The athlete's parents were instructed to take him to the physician the following week if symptoms persisted over the weekend. **Differential Diagnosis:** Anterior capsule sprain, bone contusion, proximal medial tibial physeal injury, tibial apophyseal injury, and meniscal injury. **Treatment:** Due to persistent symptoms, the athlete reported to the physician on 9/15/09. He presented non-weight-bearing with edema and effusion around the right knee. All pain and tenderness was localized to the tibial tuberosity. Active ROM was difficult and painful beyond 30° and passive ROM was full. Based on these findings, radiographs were ordered (anterior-posterior, lateral, and bilateral patellar views). Lateral radiographs revealed possible widening of the physis of the tibial tuberosity and a lateral radiograph was ordered for the contralateral knee for comparison. An MRI was ordered to confirm injury to the tibial tuberosity physis. MRI on 9/18/09 revealed increased signal in the tibial tuberosity physis, consistent with a Type I Salter-Harris injury to the tibial tuberosity. The athlete was placed in a knee immobilizer, weight-bearing as tolerated, and referred to physical therapy on 9/25/09 to begin quadriceps strengthening exercises. He was able to progress to light jogging on 10/13/09 and was released from PT and cleared for activity on 11/10/09. **Uniqueness:** The majority of physeal injuries occur in the upper extremity. Overall, more physeal injuries occur in distal physes than in proximal. Additionally, this athlete's mechanism of falling on his knee is inconsistent with the common traction mechanism associated with Type I Salter-Harris injuries. **Conclusions:** As athletes become increasingly competitive at younger ages, it becomes more important for clinicians to be aware of injuries specific to the pre-adolescent age group. Approximately 15-30% of pediatric fractures are Salter-Harris and the peak incidence of physeal injuries is at 12-13yo. Knowledge of how to identify and address physeal injuries is especially important because, when the physes are unfused, they may be 2-5 times weaker than the surrounding connective tissue. Unfused physes have poor resistance to tensile

and shear forces, which are frequently encountered in athletics, putting young athletes at risk for physeal injury. Because Type I physeal injuries can be easily misdiagnosed, it is important for clinicians to be aware of the location of physes and understand how to recognize such injuries. Unfortunately, physeal injuries are often overlooked in many athletic training programs. Clinicians that may be working with high school and middle school athletes should acquaint themselves with the location of commonly injured physes, as well as the common presentations of these injuries to help improve the assessment and treatment of their athletes.

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**Scapholunate Ligament Tear In A Female Collegiate Diver**

Albert D, Walsh J: University of South Carolina, Columbia, SC

**Background:** A 21 year old female collegiate diver was competing in a dual meet in the fall of 2008 when she felt her wrist "pop" after a springboard dive. Her mechanism of injury was completing a hand first entry into the water off the three-meter spring board. In diving, the athlete enters the water with both arms fully flexed and internally rotated with both wrists extended and overlapping each other. The athlete presented with extremely localized swelling over the lunate and capitate bones of the right wrist and hand. No other deformities were noticed. Motion was within normal limits, but extreme wrist extension was painful. When palpating the proximal border of the lunate, there was severe pain with touch. The capitate was mildly tender. As this injury did not affect her performance as a diver, she came to the athletic training room two weeks after the injury occurred only because of swelling and pain after practice and weight training. **Differential Diagnosis:** Lunate Dislocation, lunate or scaphoid fracture, scapholunate or lunocapitate ligament tear. **Treatment:** The diver received an x-ray following the athletic trainer's referral to the team physician revealing no fracture or dislocation. The athlete was subsequently referred to a hand specialist who ordered an MRI revealing evidence of a perforation of the scapholunate interosseous ligament. There was also evidence of abundant tenosynovitis. Treatment consisted of ice, taping and bracing throughout her season. She was able to compete the rest of the year as long as she could withstand the discomfort. All exercises adding stress on the wrist joint were eliminated or modified including wrist extension activities, pushups, and any exercise where the bar rested on her wrist. Naprosyn 500mg was prescribed to manage inflammation. Towards the end of her season her pain increased due to the increased training loads. For post-season competition, she was prescribed Ultram, which provided sufficient pain relief. The athlete elected to have surgery in the spring of 2009. An arthroscopic debridement of her right wrist was performed. After clearing out the fraying, the surgeon made a transverse incision between the two arthroscopic incisions on the dorsum of the wrist to focus on the localized swelling that stayed present over the lunate bone, performing an open debridement. This swelling was actually tenosynovium that revealed two rice bodies within the tissue. She was cleared to participate in diving the following season after extensive therapy during the summer. She has had flare-ups of swelling and discomfort that was unremarkable to the surgeon. Additional testing to rule out systemic diseases such as arthritis or lupus was conducted and found negative. The surgeon subsequently chose to limit anti-inflammatory steroids and the athlete has since been put on Mobic, Flector Patches and Voltaren gel to manage inflammation. **Uniqueness:** The researcher found no information regarding scapholunate ligament tears in diving. Divers put up to 35 mph of force on the wrist when entering the water. It is a unique sport in that it incorporates constant direct blows to the wrist. **Conclusions:** With the careful observation of the athlete and consideration of her training schedule by the sports medicine team, the athlete was able to complete her season successfully with the scapholunate ligament tear and tenosynovitis by winning three-meter springboard at conference and going on to NCAA championships. The diver has made a full recovery since the surgery and continues to compete in collegiate diving.

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**Groin Pain Indicates Significant Hip Injury In A Collegiate Tennis Player**

Morris LM, Black S, Uhl T: University of Kentucky, Lexington, KY

**Background:** A 20 y/o male, collegiate tennis player reported to athletic training room late January 2009 complaining of left groin pain with lateral movements and sprinting. Athlete reported a previous avulsion fracture of rectus femoris at its origin on left hip at the age of 14. On initial physical examination there were no obvious deformities, swelling, or discoloration. He had full active and passive range of motion compared bilaterally. Manual muscle testing revealed good hip strength bilaterally but increased pain with hip flexion when tested in a bent leg and straight leg position. He had a positive Thomas Test and negative FABER Test bilaterally. Athlete's activity was modified for practice and conditioning. He was treated with modalities and rehabilitation in the athletic training room for one week then referred to team doctor after symptoms did not subside. **Differential Diagnosis:** Hip flexor strain, adductor strain, re-injury of avulsion fracture. **Treatment:** Anterior-posterior and lateral x-rays of pelvis were ordered at initial complaint of injury, osteophyte noted at superior rim of left acetabulum at location of previously reported avulsion fracture, cam-morphology was also discussed. Athlete was diagnosed with hip-flexor strain. Throughout the season his symptoms were inconsistent day-to-day, although, he was able to make it through the season he never felt he played 100% and was never pain free. Second physician examination done in May 2009 revealed tenderness on adductor insertion to pelvis. His ASIS and inguinal ring were without tenderness when palpated but he did have occasional ache in testicle. His pain was reproduced with internal and external rotation of hip although he had full ROM in all planes. Athlete reported having some relief of pain with rest, but returned immediately with activity. Athlete was diagnosed with adductor strain then prescribed rehabilitation for 6-8 weeks with no tennis activity. New X-rays and MRI-arthrogram were ordered on May, 2009 to rule out intra-articular pathology. Athlete was then referred to a hip specialist who reported both X-rays revealed significant prominence from overgrowth of the AIIS and a cam morphology in the uninvolved hip. MRI revealed degeneration of lateral labrum, prominent multiloculated paralabral cyst, and mild cam morphology on left hip. He is currently recovering from surgery with the expectation to play tennis in the spring of 2010. **Uniqueness:** The uniqueness of this case is credited to athlete's previous avulsion fracture that created a "pincer-like" impingement. Athlete also has a bony abnormality in his right hip that makes it likely that he will have labral complications if he continues with high intensity and competitive sports. Femoral acetabular impingement (FAI) is new and long-term outcomes are not identified in literature. **Conclusions:** Hip injuries account for 5-6% of all adult athletic injuries, 25-55% of them are labral tears. When diagnosing athlete with groin pain suspicion of intra-articular hip pathology should increase if the following events exist: 1) athlete has previous medical history of bony injury to hip joint, 2) they are not responding to rehabilitation or rest, and 3) symptoms appear to be inconsistent as injury progresses. In ongoing cases where these signs are present it is necessary to get images that assist in ruling out other intra-articular hip pathologies. MRI with contrast and computed tomography (CT) scans have shown to be effective in showing intra-articular hip pathologies that could be caused by cam and pincer bony morphology. Early diagnosis of bony deformity will help

limit amount of articular degeneration and potentially allow return to sport with less discomfort. Currently arthroscopic repair of labrum and bony deformities have a 71% success rate without osteoarthritis (OA) and only 21% success rate when OA is present in the hip.

# Free Communications, Poster Presentations: Scapular Mechanics & Muscle Activity

Thursday, June 24, 2010, 8:00AM-11:30AM, Grand Hall, authors present 10:30AM-11:30AM

**The Relationship Between Upper Body Posture And Scapular Kinematics In Older Adults**

Varnell MV, Jaczynski A, Hansen M, Bay RC, Sauers E: Department of Interdisciplinary Health Sciences, A.T. Still University, Mesa, AZ; Banner Health SHRI-CORE Orthopedic Motion Analysis Lab, Sun City West, AZ; The CORE Institute, Gilbert, AZ

**Context:** Shoulder disorders are common in older adults. Alterations in scapular kinematics and upper body postures, including greater thoracic kyphosis (TK), greater forward head posture (FHP), and greater forward shoulder posture (FSP) have been observed in patients with subacromial impingement and with increasing age. **Objective:** To evaluate the relationship between upper body posture and scapular kinematics in older adults. **Design:** Descriptive cohort study design. **Setting:** Controlled laboratory setting. **Patients or Other Participants:** A volunteer sample of 27 (12 M, 15 F) healthy participants between the ages of 50-79 (66±8 yrs, 169±11cm, 80±16 kg) participated in this study. Inclusion criteria included no present shoulder pathology or pain and the ability to perform full, pain free, active shoulder range of motion. **Interventions:** All measures were performed on the right upper extremity. Scapular kinematics, including internal rotation (IR), upward rotation (UR), and posterior tilt (PT), were measured at four positions of humeral elevation (rest, 60°, 90°, and 120°) using an active optical tracking system (Northern Digital Inc., Optotrak Certus, Ontario, Canada) integrated with custom Labview software (National Instruments, Austin, TX). TK was measured using a C-THRU flexicurve ruler (The C-THRU Ruler Co., Bloomfield, CT) and Image J (National Institute of Health, Bethesda, Maryland). FHP and FSP were measured from a lateral photograph taken at a standardized distance and height from each subject. Spearman rank correlation coefficients were calculated to estimate the strength of the monotonic relationships within and between each of the upper body posture and scapular kinematics variables. **Main Outcome Measures:** The dependent variables for scapular kinematics (IR, UR, PT) were recorded to the nearest degree at each of the four positions of humeral elevation angle. The dependent variables for upper body posture (TK, FHP, FSP) were recorded to the nearest degree. **Results:** Means±SDs for TK, FHP, and FSP were 43°±7°, 54°±12°, and 43°±14°, respectively. A significant correlation was observed between TK and FHP (r=-0.407, p=0.035). TK was signifi-cantly correlated with scapular PT at 90° and 120° of humeral elevation (r=0.548, p=0 .003; r=0.392, p=0.043), and scapular IR at rest (r=0.407, p=0.035). FSP was significantly correlated with scapular UR at 60°, 90°, and 120° humeral elevation (r=-0.515, p=0.006; r=-0.682, p<0.001; r=-0.651, p<0.001), and scapular IR at rest (r=-0.400, p=0.039). **Conclusions:** In healthy older adults, greater TK was associated with more FHP. TK was also associated with increased PT at 90° and 120°, suggesting that greater scapular PT is required to achieve arm elevation. Greater TK and FSP were both associated with greater scapular IR at rest. Greater FSP was also associated with greater scapular UR during arm elevation. Clinicians should consider the relationships between upper body posture and scapular kinematics when developing rehabilitation strategies to improve shoulder function in older adults.

**Scapular Upward Rotation And Acromiohumeral Interval Changes In Collegiate Baseball Players During A Weighted And Un-Weighted Scaption Exercise**

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**Context:** Upward rotation of the scapula during arm abduction is thought to be important action in maintaining an open subacromial space. Most dynamic analyses of the scapula have used surface electrodes, which do no allow for concurrent dynamic analysis of the acromiohumeral interval (AHI). Scaption exercises are often prescribed in shoulder rehabilitations, yet little is known about their affect on glenohumeral kinematics. **Objective:** To determine if differences exist in scapular upward rotation (SUR) and AHI during a weighted and un-weighted scaption exercise. **Design:** Descriptive cohort study design. **Setting:** Athletic training facility. **Participants:** Twelve division one collegiate baseball players (age = 20.1±1.1 years, mass = 85.3±6.8 kg, height = 179.1±6.8 cm) with no history of surgery or current injury involving their dominant arm. **Interventions:** Participants performed three trials each of an un-weighted and weighted 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 last two trials 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. Paired t tests were used to compare weighted and un-weighted AHI and SUR at 30°, 45°, 60°, and 75° of humeral-thoracic elevation (HT angle). Pearson correlation coefficients were calculated to assess the relationships between AHI and SUR at each HT angle. **Main Outcome Measures:** One investigator (MT) performed all measurements. AHI was measured as the smallest vertical distance between the inferior acromion and superior humeral head. AHI was normalized and expressed as the percentage of space at each HT angle in reference to the AHI at 0°. SUR was measured as the angle between the inferior and superior glenoid tubercles and vertical. Upward rotation was recorded as a positive angle. **Results:** The only significant differences in AHI occurred at 75° (UWAHI = 33.1±10.1%; WAHI = 24.6±11.1%; P=.023). The only significant differences in SUR occurred at 75° (UWSUR =1.7°±8.6; WSUR = 5.8°±9.3; P =.024). Un-

weighted SUR was significantly related to AHI at 30° (r =.712; P =.009). Weighted SUR and AHI were significantly related at 30°, 45°, 60°, and 75° (r =.880, P =.001; r =.872, P =.001; r =.850, P=.002; r =.809, P =.008, respectively). **Conclusions:** The weighted scaption exercise reduced the subacromial space at 75°, but resulted in greater upward scapular rotation. Strong relationships between AHI and scapular upward rotation position were present during all weighted scaption positions, but only at 30° during un-weighted scaption. More research is necessary to determine how differences in glenohumeral kinematics during a weighted scaption exercise may affect exercise prescription.

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**Scapular Muscle Activity In Overhead And Non-Overhead Athletes During Closed Chain Exercises**

Tucker WS, Bruenger AJ, Doster CM, Hoffmeyer DR: University of Central Arkansas, Conway, AR

**Context:** Imbalances in scapular muscle activation are common in patients with shoulder impingement. Previous research did not find scapular muscle activation differences between overhead athletes with and without symptoms of shoulder impingement during closed chain exercises. It is unknown if scapular muscle activation imbalances are present during closed chain exercises in healthy overhead athletes compared to non-overhead athletes. **Objective:** To compare the muscle activation of the upper trapezius (UT), middle trapezius (MT), lower trapezius (LT) and serratus anterior in non-injured overhead and non-overhead athletes. **Design:** One-between (Group), one-within (Exercise) repeated measures. **Setting:** Controlled laboratory environment. **Patients or Other Participants:** Fifteen overhead sport athletes (OH) (10 females: 19.5±1.4 yrs, 171.3±5.1 cm, 71.5±8.5 kg, 5 males: 21.2±1.3 yrs, 188.2±6.5 cm, 95.1±8.6 kg) and 15 non-overhead sport athletes (NOH) (10 females: 19.5±1.2 yrs, 166.9±4.9 cm, 62.8±9.5 kg, 5 males: 20.2±1.3 yrs, 176.0±2.2 cm 70.7±10.4 kg) with no shoulder pathologies (NP). **Interventions:** Subjects completed five individual trials of a standard push-up (PU), supine pull-up (SP) and Cuff Link® (CL) while electromyography recorded muscle activity of the UT, MT, LT and SA on the throwing dominant side. Mean electromyography data for the four muscles were normalized to a maximum voluntary isometric contraction. The independent variables were group (OH and NOH) and exercise (PU, SP and CL). The dependant variables were the mean muscle activations of the four muscles (UT, MT, LT and SA). For each dependent variable, a 2-way repeated measures ANOVA was performed. Level of significance was set at $p<.05$. **Main Outcome Measures:** Normalized mean electromyography of the UT, MT, LT and SA. **Results:** Statistically significant main effects existed for exercise for all four muscles. The UT ($F_{2,56}$=70.118; p<0.001) was significantly more active during the SP (61.57±29.67%) compared to the PU (27.89±16.21%) and CL (5.50±2.94%). The MT ($F_{2,56}$=134.192; p<0.001) was significantly more active during the SP (62.89±24.17%) compared to the PU (21.12±13.10%) and CL (6.59±4.81%). The LT ($F_{2,56}$=41.326; p<0.001) was significantly more active during the SP (60.47±34.80%) compared to the PU (34.80±30.81%) and CL (9.67±4.34%). For UT, MT and LT, the levels of activation during the PU were significantly more compared to the CL. The SA ($F_{2,56}$=25.652; p<0.001) was significantly more active during the PU (49.97±18.86%) compared to the CL (43.81±19.70%) and SP (25.52±19.80%), while SA activation during the CL was significantly more than the SP. There were no significant influences of group on the activation of the UT, MT, LT or SA. **Conclusions:** Overhead and non-overhead athletes elicited similar levels of muscle activation during these closed chain exercises. Differences in muscle activation of the UT, MT, LT and SA existed within the exercises. Clinicians should consider the muscle of interest when including one of these exercises into an injury prevention or rehabilitation protocol.

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**Patterns Of Shoulder Pain, Disability, Impingement, And Exposure Across The Lifespan Of Female Swimmers**

Turner GN, Tate AR, Knab SE, Jorgensen C, Strittmatter A, Hoffman R, Michener LA: Arcadia University, Glenside, PA, and Department of Physical Therapy, Virginia Commonwealth University, Medical College of Virginia, Richmond, VA

**Context:** There are over 340,000 competitive swimmers in the United States (US), and the reported incidence of shoulder pain among various groups of swimmers is 40-69%. However, studies have not used consistent methods to measure shoulder pain and disability across the lifespan of swimmers to determine if a specific group may be more symptomatic and potentially benefit from training modification. **Objective:** To compare the frequency of pain, disability, shoulder impingement, and swimming exposure in competitive swimmers aged 8-77. **Design:** Cross sectional design using a survey and physical examination. **Setting:** Poolside. **Participants:** Multicenter trial of 236 females on youth, high school, or US Masters Swim teams. **Interventions:** Participants completed a questionnaire which included swimming exposure, the Disability of the Arm Shoulder Hand (DASH) Sports Module, and 3 questions from the Penn Shoulder Scale identifying pain at rest, with normal activities (eating, dressing, bathing) and with strenuous activities (sports, reaching, lifting). They underwent a physical examination by an ATC which included the Neer, Hawkins, and Jobe tests for subacromial impingement. **Main Outcome Measures:** Chi square tests were used to compare frequencies of dichotomous variables (presence of pain, swimming disability, and impingement signs) among four age groups of swimmers. ANOVAs were used to compare hours swum per week and years swum. **Results:** Significant differences between age groups were found for pain, disability, shoulder impingement, and exposure. The respective percentages of swimmers from each age group (8-11years, 12-14 years, high school aged 15-19, and masters aged 21-77) experiencing shoulder pain at rest was 7.14%, 13.95%, 28.97%, and 19.40% (P=0.025); pain with normal activity was 4.76%, 11.63%, 42.86%, and 19.40% (P<.001); and pain with strenuous activity was 30.95%, 55.81%, 80.95%, and 64.18% (P<.001). The percentage of swimmers in each age group with disability, identified as limitations in ability to swim with normal technique, practice usual amounts of time, and swim as well as desired was 19.05%, 37.21%, 65.48%, and 35.82% respectively (P<.001). Each age group had significantly different swimming exposure, with respective means of 6.9±2.4, 10.1±4.3, 16.1±6.0, and 4.0±1.7 hours swum per week (P<.001) and respective means of 3.4±1.6, 5.9±2.0, 8.0±2.8 and 16.6±14.1 years participating in competitive swimming (P<.001). The presence of at least one positive shoulder impingement test ranged from 38% to 67% with the high school swimmers having the highest occurrence rates. **Conclusions:** High school swimmers exhibit unacceptably high rates of pain, not just during strenuous activities such as swimming, but also at rest and with normal daily activities. They also exhibit the highest rates of shoulder impingement and disability and practice the greatest number of hours. Currently no guidelines for safe exposure exist. The data presented here warrant consideration of the development of safe guidelines for youth swimming exposure.

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**Change In Nociceptive Area And EMG Activity After Eccentric Exercise Of The Shoulder**

Dover GC, St-Onge N: Concordia University, Montreal, QC

**Context**: The mechanisms of pain and the cause of the decrease in the muscle contraction properties after delayed onset muscle soreness (DOMS) are unclear. The extent that pain may affect the muscles around the lesion site is unknown. **Objective:** To measure the effect of an external rotation eccentric exercise protocol of the shoulder on the nociceptive area and EMG activity of the deltoid muscle. **Design:** A single group pre-post test study. **Setting:** All testing took place in research laboratory. **Participants:** Nine healthy subjects from the university population (4 males and 5 females, height = 172.8 ± 8.2 cm, mass = 76.3 ± 16.8 kg, age = 22.2 ± 2.1 years) volunteered for this study. **Interventions:** All subjects reported to the research laboratory for baseline measurements that included range of motion (ROM), pain, evoked tenderness, and EMG activity. Evoked tenderness was measured using a visual analogue scale (VAS) and an algometer. After the baseline measurements, subjects completed an eccentric external rotation protocol on an isokinetic dynamometer until they could only generate 50% of their maximum voluntary isometric muscle contraction (MVIC). All subjects returned to the lab after 48 hours and repeated baseline measurements. Separate repeated measures ANOVAs and paired sample t-tests were used to analyze shoulder ROM, evoked tenderness, pain, and EMG activity ($\alpha$=0.05). **Main Outcome Measures:** Shoulder internal and external rotation range of motion (ROM) was evaluated and overall pain was assessed using a VAS. In addition, eleven locations were used to measure evoked tenderness over the supraspinatus, infraspinatus, deltoid muscle, and other anatomical landmarks around the glenohumeral joint. Surface EMG electrodes were used to measure muscle activity of the deltoid during an MVIC of abduction. **Results:** A significant decrease in internal ROM (ROM pre= 67.1° ±10.8; post= 43.8° ±11.3; p < .001) and a significant increase in pain was noted after exercise (VAS(mm) pre= 0.56 ±0.73; post= 35.7 ±24.8; p = .003). In addition there was a significant increase in evoked tenderness over the rotator cuff (VAS pre= 11.1 ±12.0; post= 24.3 ±24.8;p = .047). There was a significant increase in evoked tenderness around the distal portion of the deltoid (VAS pre=9.3 9.4; post= 13.8 11.0; p= .006). There was a trend toward a decrease in muscle activity in the deltoid (EMG pre=417.2 mV ±158.4; post= 326.8 mV ±133.3; p= .058) **Conclusions**: DOMS was successfully induced in all subjects. Changes in pain and evoked tenderness in areas were most significant around the lesion site but were still noted in surrounding areas of the shoulder. The increase in pain may explain the potential decrease in muscle activity in the deltoid following the exercise. Muscle activity and evoked tenderness after exercise may be affected by muscle location and fibre direction.

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# Free Communications, Poster Presentations: Biomechanical Comparison Between Sexes

Friday, June 25, 2010, 8:00AM-12:00PM, Grand Hall, authors present 11:00AM-12:00PM

**Difference In Eversion Force Sense Between Genders**

Zamarelli CM, Cecco J, Docherty CL, Grove CA, Schrader J: Indiana University, Bloomington, IN

**Context:** The majority of force sense studies have focused on how injury affects proprioceptive acuity at the ankle. However limited research has investigated how gender may affect proprioceptive acuity prior to injury. **Objective:** To determine whether differences exist between genders in ankle eversion force sense. **Design:** Repeated measures design. **Setting:** University Research Laboratory. **Patients or Other Participants:** Twenty healthy male subjects (19.05 ± 0.9 years, 175.3 ± 6.1 cm, 70.8 ± 9.3 kg) and 22 healthy female subjects (19.18 ± 0.7 years, 165.15 ± 5.5 cm, 60.8 ± 6.4 kg) volunteered for this study from a large university. Subjects were excluded if they had any lower extremity injuries, central nervous system injuries or deficiencies, or were pregnant. **Interventions:** Ankle force sense testing was performed at 10% and 30% of eversion maximal voluntary isometric contraction. Using a load cell (Sensotec, Columbus, OH), subjects were asked to produce the target force using a visual cue and hold for 5 seconds, relax, and then reproduce the force without a visual cue. Three trials were performed for each target force. The reproduction force was subtracted from the reference force to produce a trial error score. The trial error scores were then used to calculate absolute (AE) and variable (VE) error scores. Separate mixed 2x2 repeated measures analyses of variance were conducted for each error calculation, with one between subjects factor (gender at two levels) and one within subjects factor (force at two levels). **Main Outcome Measures:** Absolute and variable error scores (Newtons). **Results:** For AE, a significant main effect for gender ($F_{1, 40}$=7.18, p=.01) was found. Specifically, males (4.07 ± 0.31N) performed worse than females (2.91 ± 0.30N). We also identified a significant main effect for force ($F_{1, 40}$=15.10, p=.01). Subjects produced more errors at 30% (4.36 ± 0.36N) than at 10% (2.61 ± 0.25N). For VE, there was also a significant main effect for both gender ($F_{1, 40}$=5.65, p=.02) and force ($F_{1,40}$=24.35, p=.01). Males (3.09 ± 0.35N) were less consistent in reproducing the forces than females (1.94 ± 0.33N). All subjects were also less consistent in reproducing the 30% (3.47 ± 0.41N) force compared to 10% (1.57 ± 0.15N). No gender by force interaction was identified for either error score (p>.05) **Conclusions:** Males performed worse than their female counterparts in their ability to sense sub-maximal eversion force at the ankle. One potential explanation for this finding is that males are capable of producing higher forces. This in turn could make it more difficult for them to accurately reproduce the target forces. This inability to reproduce forces accurately should be considered when evaluating whether males may be at a greater risk of sustaining an ankle injury.

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**Individual Joint Contributions To Lower Extremity Energy Absorption Do Not Differ Between Sexes Exhibiting Similar Joint Positions At Ground Contact**

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

**Context:** Sex differences in joint contributions to lower extremity energy absorption (EA) and joint positions at initial ground contact (IGC) have been identified during vertical drop-landing tasks. While both sexes primarily use the knee to absorb energy, the next largest contributor to EA in females and males, respectively, is the ankle and the hip. Sex differences in EA strategy may contribute to an erect landing posture and greater female

ACL injury risk. However, it is unknown whether these sex differences persist during tasks with greater horizontal motion than vertical drop-landings. **Objective:** To compare joint position at IGC and joint contributions to EA across sex during a double-leg jump landing (DLJL). **Design:** Causal-comparative. **Setting:** Research laboratory. **Patients or Other Participants:** 13 Female (Age:20.77 ±0.44 years, Height:1.67±0.05 m, Mass:63.95 ±8.35 kg) and 13 Male (Age:20.38±2.99 years, Height:1.78±0.07 m, Mass:74.19±14.06 kg) volunteers. **Inter-ventions:** Subjects stood atop a 30-cm box placed 50% of their height behind a force plate and executed five DLJLs. Dominant leg kinematics and kinetics were assessed via a camera-based motion capture system and a force plate. Inverse dynamics was used to calculate net internal hip, knee, and ankle joint moments which were multiplied by joint angular velocities to derive joint power curves. Eccentric muscle activity results in negative work at a joint, thus EA for each joint was calculated by integrating the negative portions of the joint power curves during the 100 ms following IGC. **Main Outcome Measures:** Sagittal plane hip, knee, and ankle joint angles at IGC were identified. Hip, knee, and ankle joint contributions to total EA were calculated as the proportion of energy absorbed at each joint to the summed total of EA across all joints expressed as a percentage. Dependent variables were compared across sex using independent samples *t*-tests ($\alpha$=0.05). **Results:** No significant differences were identified between sexes in hip flexion (M:23.32±8.14° vs. F:23.73±5.75°, *p*= 0.885), knee flexion (M:16.86±5.63° vs. F:14.68 ±4.59°, *p*=0.290), or ankle plantarflexion (M:43.25±9.13° vs. F:45.55 ±9.40°, *p*=0.533) angles at IGC. There were no significant differences between sexes in contributions to total EA at the hip (M:26.96±12.87% vs. F:24.98±8.37%, *p*=0.647), knee (M:43.00 ±13.11% vs. F:41.02±14.34%, *p*=0.717), or ankle (M:30.04 ±12.75% vs. F:33.99±13.04%, *p*=0.442). **Conclusions:** The results of this investigation conflict with previous research reporting sex differences in joint contributions to EA and joint positions at IGC. This suggests that inherent differences between the landing tasks and/or the lack of kinematic differences at IGC in the current study contributed to the equivocal EA results. As initial joint positioning during landing could affect EA by defining the available range of sagittal plane joint motion, future research should evaluate whether previously observed sex differences in EA were the result of sex-specific EA strategies or driven by sex differences in lower extremity kinematics.

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**Gender Differences In Lower Extremity Force Output, Power, And Dynamic Balance After Aerobic Exercise**

Strobino EC, Jackson KR, Weltman A, Hertel J, Hart JM: Atlantic Physical Therapy, Virginia Beach, VA; University of Toledo, Toledo, OH; University of Virginia, Charlottesville, VA

**Context**: A gender disparity in non-contact (NC) anterior cruciate ligament (ACL) injuries favors women by 2-8 times. Previous research reporting the likelihood of NC-ACL injuries occurring later during athletic events suggest that fatigue may play a role in the NC-ACL gender disparity. **Objective**: To compare hamstring and quadriceps force output, dynamic balance, electromyographic (EMG) muscle activation, and vertical jump height (VJH) after aerobic exercise in men and women. **Design**: 2 x 2 repeated measures descriptive laboratory study. **Setting**: Laboratory. **Patients or Other Participants**: Thirty-one healthy, physically active young adults; 16 female (age=22.69±2.98 years, ht=164.11±5.01cm, mass=61.19±9.82kg) and 15 male (age=23.87±3.89 years, ht=175.34 ±10.17m, mass=81.44±14.34kg). **Intervention(s)**: All subjects performed a standardized 20 minute aerobic exercise protocol on a treadmill at 3.5miles per hour. During the first 15 minutes of exercise, the treadmill incline was increased by 1%. Subjects raised or lowered the treadmill incline during the last 5 minutes to maintain a rating of perceived exertion between 15-17 indicating that the subjects perceived the exercise was "hard(15)-to-very hard(17)". We performed planned gender comparisons using t-tests for baseline measures and individual 2X2 ANOVAs to compare genders over time. **Main Outcome Measures**: Maximal volitional isometric quadriceps and hamstrings force; normalized reach distance during the Star Excursion Balance Test (SEBT) in the anterior, posteromedial, and posterolateral directions; average root mean square activation of the vastus lateralis and biceps femoris at the point of maximum reach during SEBT (normalized to single leg standing); and single-leg vertical jump height. **Results:** At baseline, males exhibited significantly greater normalized quadriceps(0.37±0.13N/kg vs 0.53±0.15N/kg, $t_{29}$=-3.1,P=0.005) and hamstring strength (0.53±0.19N/kg vs 0.75±0.23N/kg, $t_{29}$=-3.0,P=0.006) and vertical jump height (26.9±808cm vs 37.9±10.9cm, $t_{27}$=-3.0,P=0.006) compared to women. There were no differences at baseline in normalized reach distances during the SEBT or EMG muscle activation recorded during the SEBT. After exercise, normalized reach distance in the posteromedial direction decreased regardless of gender (0.893±0.07 vs 0.876±0.07, $F_{1,29}$=5.0,P=0.03) but there were no interaction among time and gender. Quadriceps force increased following exercise regardless of gender (0.45±0.16 vs 1.02±0.34,$F_{1,29}$ =168.6, P<0.001). Both vastus lateralis and biceps femoris normalized EMG during each of the SEBT directions significantly increased but there were no interactions among gender and time. **Conclusions:** Gender differences observed at baseline are in agreement with those previously reported. These differences do not seem to be amplified by low-intensity continuous aerobic exercise. Sports-specific and higher intensity fatiguing exercise protocols may provide additional information that is applicable to settings where NC-ACL injuries occur.

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**Rate Of Torque Development Differs Between The Sexes During Time-Critical Periods**

Johnson ST, Kipp K, Hoffman MA: Oregon State University, Corvallis, OR, and University of Michigan, Ann Arbor, MI

**Context:** Rapid development of muscle torque may help protect joints in time-critical situations by increasing their resistance to perturbations and providing joint stability. Sex differences in neuromuscular performance, such as rate of torque development (RTD), may contribute to the difference in injury rates between men and women. Although previous research suggests that men and women differ in their ability to produce maximal rates of muscle torque development, it is not known whether this holds true during the early-onset phase of torque production. **Objective:** To examine sex effects on early-onset and maximal RTD parameters. **Design:** Cross-sectional. **Setting:** Research laboratory. **Participants:** Volunteer sample of 19 males (23.0 ± 4.3 yrs, 177.45±5.44 cm, 77.52 ± 13.18 kg) and 18 females (24.7 ± 2.9 yrs, 165.31 ± 5.85 cm, 62.44 ± 8.76 kg). **Interventions:** RTD was measured while seated recumbently on a Biodex System 3 dynamometer (Biodex Medical Systems, Shirley, NY) that was interfaced with a Biopac MP100 data collection system (Biopac Systems Inc, Goleta, CA). The ankle of the dominant leg was secured to the footplate at 90º and the knee flexed to 60º. Participants were instructed to isometrically plantarflex as hard and fast against the dynamometer footplate as possible. Three trials with 60 seconds rest were performed. **Main Outcome Measures:** Maximal RTD and RTD at 30 ms was calculated for each trial and averaged. The averages were then normalized to body mass. A one-way MANOVA was utilized to examine sex differences on maximal RTD and RTD at 30 ms. **Results:** The Wilks Lambda

multivariate test of overall differences among groups was statistically significant ($p < 0.05$). Univariate between-subjects tests revealed no differences between the sexes on maximal RTD (males = 4.93 ± 1.89 $n \cdot m \cdot s^{-1} \cdot kg^{-1}$, females = 4.34 ± 1.60 $n \cdot m \cdot s^{-1} \cdot kg^{-1}$; $p = 0.215$). Conversely, males had significantly greater RTD at 30 ms compared to females (males = 3.56 ± 1.38 $n \cdot m \cdot s^{-1} \cdot kg^{-1}$, females = 2.71 ± 0.81 $n \cdot m \cdot s^{-1} \cdot kg^{-1}$; $p = 0.024$). **Conclusions:** As previously reported, RTD differed between sexes. The effect of sex on RTD, however, was only apparent during the early time phase immediately after the onset of muscle torque production. The observed difference in RTD at 30ms after the onset of torque development may be important during time-critical injury situations in that it provides enough torque to sufficiently stabilize joint structures and protect against deleterious perturbations in men but not in women. Funded by the NATA Foundation Doctoral Research Grant Program.

# Free Communications, Poster Presentations: Ankle Instability

Friday, June 25, 2010, 8:00AM-12:00PM, Grand Hall, authors present 11:00AM-12:00PM

### Effect Of Fatigue On Eversion Force Sense In Individuals With Functional Ankle Instability

Wright CJ, Arnold BL: Virginia Commonwealth University, Richmond, VA

**Context:** Functional ankle instability (FAI) is a common problem following lateral ankle sprain. Force sense (FS) is the ability to accurately detect muscular force. FS impairments from injury and fatigue may contribute to instability. **Objective:** To evaluate the relationship between FS and fatigue in individuals with FAI. **Design**: Case-control with repeated measures. **Setting**: Controlled research laboratory. **Participants**: Matched by gender and side, we recruited 34 individuals with FAI (12 males, 22 females, age=24.6±4.77yrs, height=1.71±0.084m, weight=74.39±12.78kg, Cumberland Ankle Instability Tool [CAIT]=19.3±4.1) and 34 individuals with no ankle sprains or instability in their lifetime (12 males, 22 females; age=23.2±4.27yrs, height=1.69±0.076m, weight=67.94±11.27kg, CAIT=29.4±1.2). FAI subjects had at least 1 significant lateral ankle sprain and giving-way at least once per month (mean= 3.9±5.24). Both groups had no history of lower extremity fracture or surgery. **Interventions**: Three eversion FS trials were captured per load (10 & 30% of MVIC) using a load cell (Sensotec, Columbus, OH). For each trial, subjects produced a target force for 5 seconds, relaxed, then immediately recreated the force. FS was tested before and after a fatigue protocol of concentric eversion contractions against resistance of 33% of MVIC for 12min using a PrimusRS isotonic dynamometer (BTE Technologies, Hanover, Maryland). **Main Outcome Measures**: Trial error was the difference between the target and reproduction forces. Constant error (CE), absolute error (AE) and variable error (VE) were calculated from trial errors. A group by fatigue repeated measures ANOVA was performed for each error at each load. **Results**: There were no significant 2-way interactions for any variable at either load, nor were there any significant main effects for group or fatigue at 30% load ($p>0.05$). At 10% load there was a significant main effect for fatigue for all variables ($F_{CE(1,66)}=17.50$, $P<.001$; $F_{AE(1,66)}=9.85$, $P=0.003$; $F_{VE(1,66)}=5.21$, $P=0.026$). Specifically, fatigue increased error for both groups (CE: pre-fatigue= 0.71±0.12N, post-fatigue= 1.35±0.15N; AE: pre-fatigue=1.09 ±0.08N, post-fatigue= 1.50±0.13; VE: pre-fatigue=0.69±0.06, post-fatigue= 0.87±0.07). There were also group main effects for AE ($F_{1,66}=5.820$, $P=0.019$) and CE ($F_{1,66}=4.329$, $P=0.041$), but not VE ($F_{1,66}=2.957$, $P=0.090$). Specifically, FAI was associated with increased error (CE: FAI=1.259±0.157N, Control =0.797±01.157N; AE: FAI=1.510 ±0.127N; Control= 1.075±0.127N). **Conclusions**: Regardless of group, fatigue increased FS error at low loads. FS in individuals with FAI was less accurate than controls at the low load only. Group and fatigue deficits were small. However, we speculate that the combination FS deficits from injury and fatigue may be sufficient to contribute to ankle instability through inadequate muscle recruitment.

### The Relationship Between Mechanical Ankle Joint Laxity And Subjective Function

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**Context:** After an initial sprain, the development of chronic ankle instability (CAI) develops in upwards of 70% of patients. An increase in ankle joint laxity has been reported in patients with CAI. However, it is not known if this increase in joint laxity is responsible for the subjective level of function deficits also reported in these patients. **Objective:** To understand the relationship between mechanical ankle laxity and subjective function. **Design:** Descriptive study using a correlational design. **Setting:** Biodynamics Research Laboratory. **Patients or Other Participants:** One hundred and twenty subjects with unilateral CAI (55 males and 65 females, age=20.6±1.5yr., mass= 74.5±13.6kg, ht= 174.2±9.7cm) participated in the study. **Interventions:** Mechanical joint stability was measured with an instrumented ankle arthrometer. The arthrometer measured ankle joint motion for anterior/posterior translation and inversion/eversion angular displacement. Subjective level of function was assessed with the foot and ankle disability index (FADI) and foot and ankle disability index sport (FADI Sport). Bivariate correlations using Pearson Product Moments were made between all dependent variables taken on the unstable ankles. The level of significance was set a priori at $p \leq 0.05$ for all analyses. **Main Outcome Measures:** For the laxity variables: anterior displacement (mm), posterior displacement (mm), inversion rotation (°), eversion rotation (°), for subjective level of function: FADI (%), and FADI Sport (%). **Results:** Mean ± SD scores for the FADI were 87.6% ± 5.4, and 73.5% ± 10.3 for the FADI Sport. Mean ± SD for anterior transation was 14.6mm ± 2.1, for posterior translation 4.2mm ± 1.1, for inversion rotation 33.5°± 4.6 and eversion rotation 20.5 ± 3.7. Several significant bivariate correlations were identified. The strongest relationship was between anterior laxity and the FADI Sport ($r = -.88$, $p < .0001$). As scores on the FADI Sport decreased (indicating worse subjective level of function), anterior laxity increased. Similar significant results were reported for anterior laxity and the FADI ($r = -.65$, $p = .013$), as well as inversion laxity and the FADI ($r = -.53$, $p = .017$) and FADI Sport ($r = -.45$, $p = .013$). **Conclusions:** These data demonstrate that there appears to be a relationship between ankle laxity and subjective function in those with CAI. As anterior and inversion laxity increase scores on both the FADI and FADI Sport decrease. The strongest of these relationships is between anterior laxity and the FADI Sport, which may occur secondary to ligament damage that did not heal appropriately after an acute ankle sprain. Although numerous insufficiencies develop

after an ankle sprain, increased laxity may cause some of the subjective functional deficits reported in those with CAI. Therefore it is necessary to prevent increases in laxity post ankle sprain, to hopefully improve patients subjective level of function.

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**The Effects Of Functional Ankle Instability And Induced Fatigue On Ankle Stiffness**

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**Context:** Fatigue is defined as diminished ability to produce force and may be important when attempting to understand the factors that lead to functional ankle instability. Due to potential detrimental effects muscle fatigue may have on joint stiffness, it can be hypothesized that an alteration in ankle stiffness due to fatigue may lead to increased predisposition to lateral ankle sprain during athletic activity. **Objective:** To investigate effects of fatigue and functional ankle instability on ankle stiffness. **Design:** Repeated measures pre-post fatigue measurement of ankle stiffness in stable and functionally unstable ankles. **Setting:** College laboratory setting. **Patients or Other Participants:** Forty physically active subjects with no current lower extremity injury (14 men and 26 women, age = 21.7 ± 2.5 yrs, weight = 74.7 ± 20.9 kg, height = 173.3 ± 11.0 cm) were assigned to stable and functionally unstable ankle groups based on their scores on the Ankle Instability Instrument. **Interventions:** Peroneus longus fatigue was achieved via a 20% MVIC sustained hold isometric eversion fatigue protocol. Fatigue was defined as the inability to produce 10% MVIC (50% of target) for 10 consecutive seconds. **Main Outcome Measure(s):** Ankle stiffness (Nm/rad) was measured on a custom built inversion-eversion swaying cradle device. Peroneus longus EMG pre-activation amplitude (mean EMG amplitude 250ms prior to perturbation) (% MVIC) and EMG amplitude (mean EMG amplitude 500ms following perturbation)(% MVIC) were calculated. Three 2 (stable, functionally unstable) x 2 (pre-fatigue, post-fatigue) mixed model repeated measures ANOVAs were utilized for statistical analysis. **Results:** For ankle stiffness there were no significant differences between fatigue conditions (pre-fatigue = 38.03 ± 9.81 Nm/rad, post-fatigue = 38.14 ± 12.02 Nm/rad, $P = 0.51$) or stability (stable = 35.81± 8.06 Nm/rad, unstable = 40.37 ± 12.85 Nm/rad, $P = 0.29$), and there was no significant fatigue x stability interaction ($P = 0.17$). There was a significant difference between fatigue conditions for EMG amplitude ($P = .04$) with pre-fatigue EMG (15.97 ± 16.13 %MVIC) greater than post-fatigue EMG (11.72 ± 15.45 %MVIC). There was also a significant difference between fatigue conditions for EMG pre-activation ($P = .01$) with pre-fatigue EMG (28.43 ± 25.58 %MVIC) greater than post-fatigue EMG (20.92 ± 20.63 %MVIC). **Conclusions:** Following a sustained hold isometric fatigue protocol, peroneus longus fatigue decreased EMG pre-activation and EMG amplitude but did not appear to have a clear effect on ankle stiffness. These findings may begin to lay the foundation for an understanding of compensatory mechanisms utilized by athletes with functionally unstable ankles to prevent re-injury. They may also shed light on the physiological changes that occur following fatigue that pre-dispose athletes to initial or re-injury.

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**A Talar Positional Fault Is Present In Individuals With Chronic Ankle Instability**

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**Context:** The underlying mechanism of chronic ankle instability (CAI) remains unknown. However, the presence of tibiotalar and/or distal tibiofibular positional faults has been hypothesized as causal mechanisms of CAI. While distal tibiofibular positional faults have been reported, no investigation has determined if a talar positional fault is present in individuals with CAI. **Objective:** The objectives of this study were to: 1) determine if anterior talar displacement differs among uninjured controls and individuals with CAI and 2) determine cutoff scores for discriminating between controls and CAI. **Design:** Case control study. **Setting:** Controlled laboratory setting. **Participants:** Forty-eight subjects, 24 controls (21.8± 2.6yrs; 170±10cm; 73±16kg) and 24 CAI subjects (21.7±2.8yrs; 175±13cm; 71±13kg) participated. CAI patients had a previous moderate ankle sprain that required acute care, at least one recurrent sprain within six months of testing and scored <20 on the ankle joint functional assessment tool. **Interventions:** Each subject had a single lateral radiograph taken of each ankle. Subjects were positioned side lying while steps were taken to maintain a neutral position of the hip, knee and ankle to ensure a perfect lateral image. The average of three blinded measurements, taken on separate days, was recorded and used for further analysis. An independent sample T-test determined differences between the CAI involved ankle and the matched ankle of the control group. Separate paired sample T-tests determined if side-to-side differences were present between the ankles of the control and CAI groups. A receiver operating characteristic (ROC) curve determined a cutoff score for discriminating between controls and CAI. **Main Outcome Measures:** The sagittal plane talar position, relative to the tibia, was then calculated as the distance between the most anterior margin of the inferior tibia and the most anterior margin of the talar dome in millimeters. This measurement technique has good intra- (0.88) and inter-tester reliability (0.82). **Results:** The talus of subjects with CAI (3.69±1.37mm) was significantly more anterior than the talus of controls (2.65±1.24mm) ($p$=0.02). The involved CAI limb (3.69±1.37mm) was also significantly more anterior than the uninvolved CAI limb (2.98±1.61mm) ($p$=0.03). Side-to-side differences were not seen in the control group (matched involved: 2.65±1.24mm, matched uninvolved: 2.79±.27mm) ($p$=0.11). A cutoff score of 3.1mm had the greatest sensitivity (0.63) and least false positive score (1-specificity=0.41) for discriminating between controls and CAI (asymptotic significance =0.04) **Conclusions:** A talar positional fault is present in the involved limb of individuals with CAI relative to their uninvolved limb and compared to the matched limb of an uninjured control group. The presence of a talar positional fault suggests that anterior-to-posterior mobilizations of the talus relative to the tibia should be performed on individuals with CAI to correct this positional fault.

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**Lower Extremity Joint Kinematics In Individuals With Chronic Ankle Instability During A Lateral Single Leg Jump Landing**

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**Context**: Chronic ankle instability commonly develops following lateral ankle sprain. Altered lower extremity kinematics may provide rationale for mechanisms of repeated injury and instability in this population. **Objective**: To determine if individuals with mechanical (MAI) or functional (FAI) ankle instability demonstrate altered kinematics of the ankle, knee, hip and trunk compared to a control group during a lateral single leg jump landing. We hypothesized individuals with MAI and FAI would demonstrate greater joint displacement than controls. **Design**: Cross-sectional. **Setting**: Biomechanics Laboratory. **Patients or Other Participants**: Sixty-eight volunteer recreational athletes divided into 3 groups. MAI: 8 males, 13 females, age 19.9±1.0 years, height 172.5±6.7cm, mass 68.7±8.4 kg; FAI: 11 males, 12 females, age

20.3±1.6 years, height 173.4±9.4 cm, mass 70.7±11.9 kg; controls: 12 males, 12 females, age 20.0±1.2 years, height 171.1±7.1 cm, mass 65.4±9.8 kg. MAI and FAI groups reported e"2 episodes of ankle instability in the last 12 months. MAI participants had clinically lax lateral ankle ligaments while FAI and control participants did not. **Interventions**: Maximum vertical jump in a lateral direction was measured. Reflective markers were attached to the body using a modified Helen-Hayes marker set. Participants were positioned 70cm lateral to a force platform and asked to perform a jump to 50% of their maximum height. Participants landed on the involved leg and balanced for 8s. Kinematics and kinetics were collected using a 7-camera system (240Hz) synchronized with a force platform (1200Hz). One-way ANOVAs tested for group differences utilizing Tukey post-hoc testing at $\alpha$=0.05. **Main Outcome Measures**: Ankle, knee, hip, and trunk displacement values in 3 planes were calculated in the 1s after foot contact, identified by vertical ground reaction force. Variables were averaged over 10 trials. Participants also completed the Cumberland Ankle Instability Tool (CAIT). **Results**: Groups were not different in age, height, weight, or jump height (P>0.21). The MAI (18.0±3.2) and FAI (19.7±3.4) groups reported significantly lower ankle joint function (P<0.001) than the controls (28.5±1.5) on the CAIT. The FAI group (15.5°±4.0) demonstrated significantly greater ankle frontal plane displacement than the MAI group (12.7°±2.3°) (P=0.02). The MAI group (17.4°±5.1°) demonstrated significantly less ankle transverse plane displacement (21.1±4.0) (P=0.03) than controls and significantly less hip frontal plane displacement (20.7°±2.4°) than controls (23.3°±3.7) (P=0.03) during landing. No other group differences were noted. **Conclusions**: The MAI group appears to limit ankle and hip joint displacement during lateral jump landings compared to controls, while the FAI group did not display similar patterns. Centrally mediated kinematic changes have been proposed as a contributing factor for ankle instability, and decreased joint displacements may indicate lack of flexible landing strategies in the MAI group. The ability to teach and adapt landing strategies may be an important component in ankle sprain rehabilitation.

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**Optimal Intensity Stochastic Resonance Stimulation Improves Single Leg Balance In Stable And Unstable Ankles.**

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**Context:** Single leg balance is used for rehabilitation to improve sensorimotor impairments. Therapeutic interventions that enhance balance may have implications for facilitating rehabilitation of functional ankle instability (FAI). Stochastic resonance stimulation (SRS) has improved single leg balance, but maximizing these balance improvements with a customized optimal intensity has not been examined. **Objective:** Our objective was to determine single leg balance improvements associated with SRS administered at a customized optimal intensity for subjects with and without FAI. **Design:** A two-group (FAI, no FAI), two-treatment ($SRS_{on}$ $SRS_{off}$) cross-over design. **Setting:** Research laboratory. **Patients or Other Participants:** Ten uninjured subjects without FAI (168.4±5.7 cm, 60.6±6.1 kg, 21.6±1.2 yrs) and 10 subjects with FAI (172.5±7.6 cm, 67.3±10.1 kg, 22.5±3.1 yrs) who reported "giving-way" sensations at their ankles and recurrent ankle sprains with physical activity (sprains=3.0±1.8, "give-ways"/week=0.54±0.62). **Interventions:** Vibrating tactors were placed over peroneal, anterior tibialis, gastrocnemius, and posterior tibialis muscles on the leg with FAI or a matched test leg of uninjured subjects. A random noise signal generated in a stimulation unit caused the tactors to vibrate (SRS). A customized optimal intensity was determined by finding the intensity that produced the slowest center-of-pressure velocity during double leg balance. Subjects then performed a single leg balance test without vision or shoes under $SRS_{on}$ and $SRS_{off}$ conditions. The $SRS_{on}$ condition was administered at the customized optimal intensity. Subjects performed 3 trials for each condition and were asked to remain as motionless as possible for 20 s. A two-factor mixed-model repeated measures ANOVA with 1 within treatment factor ($SRS_{on}$, $SRS_{off}$) and 1 between group factor (FAI, no FAI) was used for analysis for each outcome measure ($\alpha$=.05). **Main Outcome Measures:** Anterior/posterior (A/P) and medial/lateral (M/L) balance were quantified with center-of-pressure velocity (COPV), center-of-pressure excursion (COPE), and 95$^{th}$ percentile center-of-pressure area ellipse (COPA-95). Lower values indicated improved balance. **Results:** Significant main effects for treatment were found, indicating that $SRS_{on}$ improved balance over the $SRS_{off}$ condition (1. A/P COPV: $F_{(1,18)}$=8.54, P=0.009, $SRS_{on}$=0.63±0.14 cm/s, $SRS_{off}$=0.69±0.17 cm/s; 2. M/L COPV: $F_{(1,18)}$=6.12, P=0.024, $SRS_{on}$=0.36±0.14 cm/s, $SRS_{off}$=0.40±0.17 cm/s; 3. M/L COPE: $F_{(1,18)}$=8.90, P=0.008, $SRS_{on}$=0.15±0.05 cm, $SRS_{off}$=0.17±0.05 cm; 4. COPA-95: $F_{(1,18)}$=9.61, P=0.006, $SRS_{on}$=1.15±0.49 cm$^2$, $SRS_{off}$=1.48±0.75 cm$^2$). No significant main effect was found for A/P COPE ($F_{(1,18)}$=3.66, P=0.072, $SRS_{on}$=0.28±0.06 cm, $SRS_{off}$=0.31±0.12 cm). No significant main effects for group (P>0.05) or treatment by group interactions (P>0.05) were found. **Discussion:** SRS administered at a customized optimal intensity improved balance between 9-22% over our control condition. SRS reduced M/L COPE, COPA-95, A/P COPV, and M/L COPV. Clinicians may consider administering SRS at a customized optimal intensity to facilitate single leg balance improvements during rehabilitation.

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**Startle Response Of The Ankle Musculature In Reaction To Repeated Inversion Perturbations**

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**Context:** When the ankle is unexpectedly forced into inversion, the activity of the primary invertor of the ankle may be negating the protective mechanism provided by the primary evertor through a "startle" response, which would cause co-contraction. **Objective:** To determine if the startle response is present during repeated simulated ankle sprain exposures and if a previous ankle sprain affects this response. **Design:** A 3 x 3 repeated measures study. **Setting:** The study was performed in a controlled laboratory setting. **Participants:** Thirty seven healthy volunteers (age=21.54±1.28 years, mass=74.24±17.03 kg, height=1.75±0.091 m), which included 13 with no previous ankle sprain, 14 with a previous lateral ankle sprain, and 10 with a previous high ankle sprain. **Interventions:** The independent variables were ankle injury history, with three levels (no ankle sprain, previous lateral, and previous high ankle sprain) and startle event, with three levels (startle event 1, 2, and 3). The first trial was treated as a separate startle event, since it was the first time the participants were exposed to the inversion perturbation. Trials 2-5 and trials 6-10 were averaged to create the second and third startle events. Statistical analysis included a 3 x 3 ANOVA with repeated measures on startle event to analyze the difference in muscle activity between the injury histories and startle events. Muscle activity was recorded with a multichannel electromyography (EMG) amplifier/processor unit (MyoClinical, Noraxon USA INC; Scottsdale, AZ) using bipolar Ag/AgCl disc surface electrodes placed over the muscle belly of the peroneus longus and tibialis anterior. An outersole with fulcrum was placed on the bottom of the participants' shoe that forced them into 25° of inversion upon landing from a 27 cm single leg drop landing. Ten trials were performed, using the dominant ankle

of the no injury group and the previously injured ankle of the two prior injury groups. **Main Outcome Measures:** The dependent variable was the ratio of evertor activity to invertor activity 200 milliseconds before and after perturbation. A ratio of 1.00 indicates equal activity in both muscles, a ratio greater than 1.00 indicates greater activity in the peroneus longus, and a ratio less than 1.00 indicates greater activity in the tibialis anterior. **Results:** There was a significant main effect for startle event ($F_{2, 34}$=9.20, $p$=.001, $\eta^2$=.286), with Fischer's LSD revealing a significant difference between startle event 1 (mean=1.58±1.06) and event 2 (mean= 2.32±1.22, $p$=.001) and startle event 1 and event 3 (mean=2.39±1.02, $p$=.001). **Conclusions:** The ratio of evertor to invertor activity increased after repeated exposures to the inversion perturbation, indicating the protective mechanism of the peroneus longus increased. Future research should investigate if the ankle musculature can be trained to provide a larger response of the peroneus longus when exposed to an initial inversion perturbation.

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### Intrinsic Foot Muscle Activation During Short Foot And Towel Crunch Exercises

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**Context**: The short foot and towel crunch exercises are used in early rehabilitation to activate the intrinsic foot muscles. Towel crunch exercises (TCE) involve repeated flexion of the distal phalanges which may involve more extrinsic foot muscles compared to intrinsic foot muscles. The short foot exercise (SFE) involves repeated contractions that narrow and shorten the foot without flexion of the distal phalanges. The SFE may be more effective than the TCE in activating the intrinsic foot muscles. **Objective**: To determine if there is a difference in abductor hallucis activation as measured by surface electromyography (sEMG) during the SFE and TCE. **Design**: Crossover. **Setting**: Athletic training laboratory. **Patients or Other Participants**: Thirty-seven healthy subjects participated in the study without a history of lower extremity injury in the last six months (11 males, 26 females; 25.27±5.40 years, 164.70±9.05cm, 71.74±13.92kg). **Intervention(s)**: Participants reported to the lab for the first visit and were instructed on how to properly perform the TCE and SFE exercises. Once the exercises were performed correctly, participants completed one set of ten repetitions for each exercise while sEMG simultaneously recorded abductor hallucis activation. Participants were dismissed and practiced three sets of ten repetitions of each exercise every day until they reported for the second visit. The second visit was within 3-5 days of the initial visit. After a brief, standardized warm-up at the second visit, participants performed ten repetitions of each exercise while sEMG simultaneously recorded activation of the abductor hallucis . **Main Outcome Measures**: Activation during the exercises was normalized to abductor hallucis activation during quiet sitting for each visit. Muscle activation during the exercise was quantified with normalized mean of the root mean square (mRMS). Normalized means for one-second samples from four separate repetitions of both exercises were calculated for both visits. The investigator analyzing the data for each repetition was blinded to the type of exercise. Dependent t-tests compared means between exercises and during the first and second visits. Alpha level was set at p<0.05. **Results**: The normalized mRMS was not significantly different between both the TCE (25.7% ±18.2) and the SFE (31.2% ±38.3) on the first visit (p=0.360). There was not a significant difference in activation of the abductor hallucis between the TCE (20.9% ±23.3) and the SFE (25.4% ±32.9) on the second visit (p=0.340). **Conclusions**: Both TCE and SFE demonstrated similar activation of the abductor hallucis . It has been established previously that the abductor hallucis is an important muscle for supporting the medial longitudinal arch. Clinicians may use either exercise to activate the abductor hallucis muscle.

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### Decreased Hoffmann Reflex Modulation Of The Soleus But Not The Peroneals With Chronic Ankle Instability

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**Context:** Hoffmann (H) reflex modulation between different body postures has been linked to postural stability. It is hypothesized that the decreased modulation between increasingly complex postures may be a potential mechanism of postural instability. Decreased modulation may be a potential mechanism for postural control deficits related to chronic ankle instability (CAI). **Objective:** To assess H-reflex modulation of the peroneals and soleus between prone and bipedal standing in subjects with and without CAI. **Design:** Case control. **Setting:** Laboratory. **Patients or Other participants:** Fourteen subjects with unilateral CAI (8 males, 6 females; age=19.9±6.0 yrs; height= 174.4±7.5 cm; mass=72.6±12.8 kg) and 14 matched controls without any history of ankle sprains (8 males, 6 females; age=20.1±4.2 yrs; height=175.2±9.8 cm; mass=72.4±18.4 kg) participated. **Interventions:** The independent variables were group (CAI, control) and limb (involved, uninvolved). Limbs of the controls were side matched to the involved limbs of the CAI subjects. Maximum H-reflexes and motor (M) waves were recorded bilaterally from the soleus and peroneals while subjects lied prone and then stood in quiet bipedal stance. Two-way ANOVAs with repeated measures on limb were performed to compare H-reflex modulation between groups and limbs for both muscles. Tukey's HSD tests were conducted for post-hoc comparisons. The alpha level was set at <0.05. **Main Outcome Measures:** The H-reflexes were normalized to the motor (M) waves to obtain H:M ratios for both body positions. To quantify the reflex modulation between positions, difference scores were calculated by subtracting the standing H:M ratios from the lying H:M ratios. **Results:** There was significant group by limb interaction for reflex modulation of the soleus ($P$=0.007). In the CAI group The H-reflex modulation in the involved limb (0.09±0.15) was significantly lower than the contralateral uninvolved limb (0.23±0.12) and the both limbs in the control group. There were no significant side-to-side differences in the control group for the soleus (control "involved"=0.20±0.15, control "uninvolved" =0.17±0.15). For the peroneals, neither the group by limb interaction ($P$=0.116) nor the group main effect ($P$=0.378) were statistically significant (CAI involved= 0.03±0.12,CAI uninvolved= 0.12±0.10,control "involved" =0.10± 0.13,control "uninvolved" =0.11±0.11). **Conclusions:** Decreased H-reflex modulation in the soleus, as assessed by the difference scores in H:M ratios between lying and bipedal standing, was present in the CAI involved limbs compared to the CAI uninvolved limbs and both limbs of the control group. Similar results were not found in the peroneals. The reduced ability of sensorimotor system to down regulate H-reflex in more demanding postures implies postural instability, which may be a potential mechanism of postural control deficits associated with CAI.

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**Weight Bearing Ankle Dorsiflexion And Anterior Reach Measurements In Chronic Ankle Instability Subjects**

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**Context**: Chronic ankle instability (CAI) may lead to restrictions in ankle range of motion and dynamic balance. Ankle dorsiflexion range of motion is an important outcome measure following ankle sprain. Functional tasks such as lunging and balancing help clinicians identify impairments that may benefit from rehabilitative treatment. However, isolated ankle joint range of motion deficits may be small and simple range of motion testing may not detect neuromuscular impairments. Impaired neuromuscular control in subjects with CAI may exacerbate ankle dorsiflexion restrictions that may not be revealed with other standing dorsiflexion range of motion assessment. **Objective**: The purpose of our study was to evaluate three methods to assess ankle dorsiflexion between: 1) healthy subjects, 2) copers who have a history of a single ankle sprain more than 12 months ago without persistent symptoms, 3) subjects with CAI. **Design**: Cross sectional. **Setting**: Laboratory. **Patients or Other Participants**: Fourteen individuals with self-reported CAI (3 males, 11 females, age=21.79±2.19 years, height=171.45±6.88 cm, mass=64.22±8.63 kg, previous sprains=4.29±2.76, FAAM Sport=70.31±11.93%), 14 copers (4 males, 10 females; age=23.21±2.78years, height =171.09±6.95cm, mass =69.71±12.37 kg, previous sprains=1.07±0.27,FAAM Sport =96.88±5.88%), and 14 healthy controls (3 males, 11 females, age=23.14±4.83 years, height=169.09±10.10 cm, mass=73.06 ±14.47 kg,previous sprains=0.00±0.00,FAAM Sport=99.33±1.81)participated. **Intervention(s)**: The independent variable was group (control, coper, CAI). **Main Outcome Measures**: Three different weight bearing dorsiflexion tasks were performed: standing straight-knee dorsiflexion ROM, standing bent-knee dorsiflexion ROM, and the anterior reach direction of the star excursion balance test (SEBT). Each task was performed three times and the mean was calculated. The SEBT was normalized to limb length. For each dependent variable, a 1x3 ANOVA was performed. Fisher's LSD post hoc tests were performed on any statistically significant findings. Alpha was set *a priori* at p<.05. **Results**: There were no statistically significant differences for standing dorsiflexion ROM with straight-knee (p=.28; control= 32.9±5.88°, coper=30.00±5.98°, CAI=28.81 ±8.44°) or with bent-knee (p=.47; control= 35.62±6.56°, coper=33.38±7.05°, CAI=32.10 ±8.88°). A significant difference was found between groups for the anterior reach test (p=.04). The CAI group (64.41±5.50%) had a significantly decreased normalized anterior reach score compared to controls (68.51±3.71%, p=.03), but not the copers (68.23±4.60%, p=.08). **Conclusions**: The anterior reach test, a weight bearing dynamic balance task, requires the individual to balance on a single limb and simultaneously dorsiflex the ankle while reaching out with the other. This combination of motor tasks may reveal functional ankle deficits that isolated range of motion testing may not detect in subjects with CAI. Ankle injury may impair neuromuscular control and that impairment may be manifested in balance and reach tasks, but not simple weight bearing dorsiflexion tasks.

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**The Effect Of Sex Differences And Hormone Fluctuation On Ankle Stability And Function**

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**Context:** Hormone fluctuation as a risk factor in ACL injury has been investigated with conflicting results; while the influence of hormone fluctuation on ankle laxity and function has not been investigated adequately. **Objective:** To examine the potential hormone contributions to ankle laxity and dynamic postural control at pre- and post-ovulatory phases of the menstrual cycle, with an ankle arthrometer and the Star Excursion Balance Test (SEBT), respectively, in healthy females with a cohort group of male control subjects. **Design:** Cohort design. **Setting:** Research Laboratory. **Patients or Other Participants:** Twenty healthy females (23.8±6.50yrs; 163.88±8.28cm; 63.08±12.38kg) and twenty healthy males (23.90±4.15yrs; 177.07± 7.60cm; 80.57±12.20kg) volunteered in this study. **Interventions:** Female subjects utilized ovulation kits for three months to determine the time of ovulation and were tested in the laboratory with an ankle arthrometer and the SEBT corresponding to their pre- and post-ovulatory time periods. Males were tested at similar dates as a control comparison. **Main Outcome Measures**: To assess ankle stability, anterior/posterior (A/P) loading was performed first followed by inversion/eversion (I/E) loading. Three trials were completed in each direction on each ankle, with total A/P (mm) and I/E (degrees) excursions used as the two dependent variables. For dynamic postural control, a custom made mat with eight measuring tapes rigidly fixed at 45º angles to each other was used to assess reaching distance in the SEBT. The posteriormedial reaching distance was used, with four practice trials followed by five test trials. The reaching test was performed on each leg, with the mean maximum reaching distance normalized to leg length (% leg length) used as the dependent variable. For each dependent variable, a Time (Pre-ovulation, Post-ovulation) by Side (Dominant, Non-dominant) by Sex (Male, Female) repeated measures ANOVA was performed. Statistical significance was set *a priori* at P<.05. **Results:** For A/P laxity there was a statistically significant Side main effect ($F_{1,38}$ = 10.93; P=0.002). The dominant limb presented with significantly greater total A/P laxity (15.89±3.28mm) compared to the non-dominant side (14.49±2.95mm). For I/E laxity there was a significant main effect for Sex ($F_{1,38}$ = 10.75; P=0.002).The females presented with significantly greater laxity (63.49±10.08deg) compared to the males (55.59±8.34deg). For the posteriormedial reaching task, there was a significant main effect for Sex ($F_{1,38}$ = 8.72; P=0.005).The females presented with significantly less normalized reaching distance (81.7±11.1 %) than the males (91.9±11.4 %). There were no significant influences of Time on the dependent variables. **Conclusions:** While females presented with more ankle I/E laxity and reduced dynamic postural control, hormone fluctuation during the menstrual cycle (pre-ovulatory compared to post-ovulatory) did not have an effect on ankle laxity or dynamic postural control, two factors that are associated with ankle instability. Perhaps this intrinsic factor does not influence ankle pathology strongly. This project was supported by the NATAREF Osternig Masters Grant Program

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**Greater Q Angle Negatively Affects Jump Performance**


Shimokochi Y, Uota S, Ambegaonkar JP: Osaka University of Health and Sport Sciences, Kumatori-cyo, Osaka, Japan, and George Mason University, Manassas, VA


**Context:** Several lower extremity alignment (LEA) measures have been suggested to influence joint function during physical activity. Functional stretch-shortening cycle activities such as jumping are often performed during physical activity. Still little research has examined how LEA measures affect jump performance parameters. **Objective:** To examine the relationships between LEA measures and jump performance. **Design:** Correlational **Setting:** Controlled laboratory **Participants:** 64 (35 males, 29 females) Japanese competitive athletes (168.5±9.3cm, 63.8±8.7kg, 19.7±1.1yrs) with no current lower extremity injuries. **Interventions:** We recorded the following LEA measures: quadriceps angle (QA, °), tibiofemoral angle (TFA, °), hip anteversion in prone (HVprn, °) and supine (HVspn, °), and navicular drop (ND, mm). Participants performed two types of jump tasks a maximal vertical jump (VJ) and rebound drop jump (RDJ) three times each from a 45cm box on a mat switch, which measured flight duration and contact time during the RDJ. Jump height ($J_{height}$) were calculated from flight durations ($F_{duration}$) as $J_{height}=1/8*g*F_{duration}$. **Main Outcome Measures:** QA, TFA, HVprn, and HVspn were measured to the nearest degree while ND was measured to the nearest millimeter. Flight duration and the contact time were measured in milliseconds. As drop jump ability comprises of both contact time and jump height ($VJ_{height}$), we calculated the $RDJ_{index}$ by dividing jump height with contact time during RDJ. Average values of three measurements in each LEA measure and the jump tasks for each participant were used for analyses. Each averaged LEA measures were further averaged across both legs. Two, separate stepwise multiple regression analyses were conducted to predict $VJ_{height}$ and $RDJ_{index}$ with the five LEA measures as predictor variables. **Results:** Day-to-day measurement consistencies for all measures were excellent ($ICC_{2,k}$ ranges: 0.82-0.97). QA was the only significant predictor that entered in the models for both $VJ_{height}$ and $RDJ_{index}$. QA predicted 14.7% of variance in $VJ_{height}$ (B=-0.979, p=0.002). Similarly, QA predicted 10.7% of variance in $RDJ_{index}$ (B=-0.044, p=0.008). Greater QA was related with lesser $VJ_{height}$ and $RDJ_{index}$. **Conclusions:** Our results indicated that participants with greater Q angles had lesser ability to perform jump tasks. The QA is traditionally considered to reflect the direction of quadriceps muscle (i.e. rectus femoris) force vector. The negative effect of QA on jump performance observed may be due to decreased efficiency in knee extensor mechanisms because of increased lateral quadriceps muscle force component. The structure and function of muscle-tendon units has been previously suggested to be factors influencing the ability to jump. However, LEA measures, specifically Q angle may be a possible factor affecting the ability to perform jump tasks., The influences of LEA measures on functional athletic performance should also be further investigated to provide better feedback to athletes and coaches to allow for improved injury prevention and performance enhancement programs.

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**Neuromuscular Fatigue And Verbal Feedback Cause Changes In Knee Kinematics And Kinetics**


McGrath ML, Padua DA, Stergiou N, Blackburn JT, Lewek MD, Giuliani C: University of North Carolina, Chapel Hill, NC, and University of Nebraska at Omaha, Omaha, NE


**Context**: Certain landing mechanics are related to increased risk of non-contact injury to the anterior cruciate ligament (ACL). However, research has not yet determined how knee kinetics and kinematics are altered due to neuromuscular fatigue, a condition believed to further increase injury risk. Additionally, interventions like verbal feedback have not been tested under fatigued conditions. **Objective**: To quantify the effects of fatigue and verbal feedback on knee joint kinematics and kinetics during an unanticipated sidestep cut. **Design**: Cross-sectional. **Setting**: Research laboratory. **Patients or Other Participants**: Fifty-nine club-sport athletes (31M, 28F; 19.8±1.6yrs, 176.7±9.2cm, 71.2±10.0kg) were randomly assigned to either receive verbal feedback (FB) or no feedback (NFB) post-fatigue. **Interventions**: The unanticipated sidestep cutting task involved a jump over a hurdle, triggering a randomized directional cue. The subject landed with the dominant foot on a force platform and cut 60° in the indicated direction. Participants then performed an intense, intermittent fatigue protocol involving multi-directional sprints and broad jumps. Testing procedures were repeated post-fatigue, but the FB group received instructions to "land softly, keep your knee over your toes, and make the movement 'smooth'". The NFB group received no instruction. **Main Outcome Measures**: Peak three-dimensional kinematics [knee flexion, valgus, and internal/external rotation (IR/ER)] and kinetics [vertical ground reaction force (VGRF), knee extension moment (KEM), knee valgus moment (KVM), and anterior tibial shear force (ATSF)] were calculated during the first 40% of the stance phase [initial contact (IC) – toe-off]. Knee joint angles were also calculated at IC. Force variables were normalized to body mass (%BM), and moment variables normalized to body mass*body height (%BM*BH). Comparisons were made between the FB and NFB groups pre- and post-fatigue using mixed-model ANOVA's with Bonferroni post-hoc tests for significant results ($a<0.05$). **Results**: Significant fatigue x group interactions were observed for ATSF ($F_{1,53}=6.783$, $P=0.012$), VGRF ($F_{1,55}=14.259$, $P<0.001$), and KEM ($F_{1,53}=4.367$, $P=0.041$). The FB group demonstrated decreased VGRF (-6.7%, $P=0.004$) and KEM (-4.9%, $P=0.019$), while the NFB group demonstrated increased ATSF (+32%, $P=0.011$) and VGRF (+8.0%, $P=0.019$). Fatigue caused significant decreases in knee flexion (-23.9%, $F_{1,54}=35.020$, $P<0.001$), valgus (-185.5%, $F_{1,54}=4.964$, $P=0.030$), and increased ER (+91.0%, $F_{1,54}=24.740$, $P<0.001$) at IC. Fatigue also decreased peak knee valgus (-38.9%, $F_{1,54}=11.426$, $P=0.001$) and IR (-95.5%, $F_{1,54}=25.452$, $P<0.001$), but increased ER (+59.9%, $F_{1,54}=26.014$, $P<0.001$). **Conclusions**: Fatigue caused an increase in VGRF and ATSF, but the use of feedback corrected these changes and decreased VGRF and KEM. However, feedback was ineffective at altering IC and peak knee kinematics post-fatigue. Feedback may have cued subjects to use more efficient, phased, and coordinated action of muscles and joints in the extremity, compensating for fatigue-related impairments in kinetics despite no changes in knee kinematics. Therefore, feedback may be one method to protect the ACL from injury under fatigued conditions.

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**Comparison Of Energy Absorption Strategies During A Terminal Vs. Non-Terminal Landing Task**

Tritsch AJ, Montgomery MM, Schmitz RJ, Shultz SJ: University of North Carolina at Greensboro, Greensboro, NC

**Context:** Muscular energy absorption describes the global strategy used to decelerate the body during a landing task. Lower extremity energy absorption strategies have been examined during both drop jump (DJ) and drop landing (DL) tasks. However, research directly comparing biomechanical responses between a terminal landing (e.g. DL) versus a landing followed by a subsequent action (e.g. DJ) are limited. **Objective:** To compare lower extremity energy absorption at the hip, knee and ankle during the deceleration phase of a DL versus DJ task. **Design:** Descriptive cohort. **Setting:** Research laboratory. **Participants:** Nineteen (10F, 9M) healthy, recreationally active college students (21.3±2.9 yrs, 173.7±7.0 cm, 71.2±9.2 kg) who were experienced with jumping and landing activities, and had no history of lower extremity injury in the past 6 months. **Interventions:** Participants dropped from a height of 45 cm and were instructed to perform either a double-leg landing (DL) or a double leg landing followed immediately by a maximal vertical jump and subsequent landing (DJ). The DL and DJ order was counterbalanced across subjects. Kinetic (1000 Hz) and kinematic (100 Hz) data were simultaneously collected on the dominant stance limb (stance limb when kicking a ball). The average values over 5 trials were analyzed. **Main Outcome Measures:** Lower extremity joint energy absorption ($JxBW(N)^{-1}xHt(m)^{-1}$) was calculated for the hip, knee and ankle from foot contact until center of mass reached its minimum. A 2 (DJ, DL) x 3 (hip, ankle, knee) repeated measures ANOVA examined differences in hip, knee and ankle energy absorption between the DJ and DL tasks. Pairwise comparisons (Bonferroni correction) further examined significant interactions. **Results:** Significant differences by task [DJ (-0.064±0.016) > DL (-0.058 ±0.015); P=0.011], joint (Hip (-0.070±0.030) = Ankle (-0.081±0.021) > Knee (-0.032 ±.0.015); P<0.001) and task by joint (P<0.001) were identified. Pairwise comparisons of the task by joint interaction revealed similar energy absorption at the ankle (-0.079±0.023 vs. -0.082 ±0.022) and knee (-0.032±0.016 vs. -0.032 ±0.016) for DJ vs. DL conditions, but greater hip energy absorption during DJ vs. DL (-0.080 ±0.032 vs. -0.060±0.031; P=0.001). This resulted in different relative contributions of the hip, knee, and ankle to work absorption between the two tasks [DJ: Hip (41.9%) = Ankle (41.4%) > Knee (16.8%); DL: Ankle (47.1%) > Hip (34.5%) > Knee (18.4%)]. **Conclusions:** Substantial differences in absolute hip energy absorption, thus distribution of relative energy absorption across joints, were identified between the DJ and DL tasks. Specifically, greater absolute and relative energy absorption occurred about the hip when a subsequent jumping action occurred. These joint specific task differences should be considered when designing activities intended to tax the lower extremity musculoskeletal system.

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**Abdominal Hollowing Does Not Affect Trunk And Knee Kinematics During A Single Leg Squat**

Goerger BM, Padua DA: Sports Medicine Research Laboratory, University of North Carolina at Chapel Hill, Chapel Hill, NC

**Context:** Recent evidence suggests that trunk stability influences knee biomechanics and injury. Abdominal hollowing is a common exercise used to improve trunk stability. However, it is unknown if abdominal hollowing alters trunk and knee kinematics during a functional task. **Objective:** To determine if performance of abdominal hollowing alters trunk and knee kinematics during a single leg squat. **Design:** Randomized Controlled Trial **Setting:** Research laboratory. **Patients or Other Participants:** Twenty-five healthy, physically active subjects were randomly assigned to either an Intervention (INV) group (n=13, Age: 21.77±2.52 yrs, Height: 168.22±8.65 cm, Mass: 68.10±7.45 kg) or Control (CON) group (n=12, Age: 22.25±3.14 yrs, Height: 171.05±9.74 cm, Mass: 72.03±16.18 kg). **Interventions:** Subjects assigned to the INV group received instruction and practiced abdominal hollowing in a crook lying position. Instruction included verbal, tactile, and visual feedback. To confirm proper performance of the maneuver, images of the antero-lateral abdominal muscles were collected at rest and during abdominal hollowing with diagnostic ultrasound. Both groups performed two trials of single leg squats, which consisted of five continuous squats. The INV group was instructed to perform the abdominal hollowing maneuver during the second set of squats, as the CON group received no instruction. Kinematic data of the test leg and trunk were collected during the trials using an electromagnetic tracking system. **Main Outcome Measures:** The change in transversus abdominis thickness was calculated for the INV as a percentage; the difference between muscle thickness at rest and during abdominal hollowing relative to the resting muscle thickness. Sagittal and frontal plane displacement of the trunk and knee were calculated during the descent phase of each squat trial. Change scores between sets were calculated for each subject. Independent samples t-tests were used to assess the difference in mean change scores between the INV and CON groups. **Results:** The INV group had a mean increase of 67.47±29.65% for the transversus abdominis during the abdominal hollowing maneuver. There was no significant difference between groups for sagittal plane trunk displacement (INV: 1.02±4.39º CON: 1.66±3.51º $p$=0.696), frontal plane trunk displacement (INV: -0.59±2.12º CON: -0.12±1.85º $p$=0.559), sagittal plane knee displacement (INV: 0.65±4.11º CON: 0.11±5.92º $p$=0.793), or frontal plane knee displacement (INV: -0.91±1.20º CON: -0.30±1.20º $p$=0.667). **Conclusions:** Findings indicate that abdominal hollowing does not alter sagittal or frontal plane trunk or knee kinematics during a single leg squat. Abdominal hollowing is commonly used to treat low back pain, but may not have an effect on trunk or lower extremity motion. However, it should be noted that our subjects were healthy, received only an acute intervention, and performed a relatively low demand task. Future research should focus on addressing these limitations.

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**Relationships Between Static And Dynamic Clinical Measurements And 3-D Knee Moments During A Single-Leg Stop-Jump Task**

Munger LM, Sizer PS, Brismee JM, James CR: Texas Tech University Health Sciences Center, Lubbock, TX, and Texas Tech University, Lubbock, TX

**Context:** Increased frontal and transverse plane knee moments during dynamic activities have been reported to increase stress on the anterior cruciate ligament (ACL) and may be risk factors for non-contact ACL injury. While inadequate strength of the hip musculature and altered dynamic performance of the lower extremity have been proposed as risk factors, little research has examined their relationship with knee moments during functional tasks. **Objective:** The purpose of the study was to examine the relationships between static and dynamic clinical strength measurements, dynamic hip control variables, and frontal and transverse plane knee moments during a functional task. It was hypothesized that static and dynamic clinical strength and dynamic hip control measurements would predict the magnitudes of frontal and transverse plane knee moment variables. **Design:** Exploratory design using multiple regression procedures. **Setting:** A clinical biomechanics research laboratory. **Participants:** Fifty-eight (32 women, 26 men) healthy, collegiate athletes (age = 20.2 ± 1.6 years, mass = 73.5 ± 11.8 kg, height = 1.77 ± 0.09 m), free of injury and neurologic deficits, were recruited to participate in the study. **Interventions:** Single-leg stop jump

tasks were performed onto a force platform (Bertec Corporation, Columbus, OH). Ground reaction force (1200 Hz), kinematics (120 Hz), and joint kinetics (inverse dynamics) were obtained using an 8-camera 3D motion measurement system (Motus 8.1.0; Vicon-Peak, Englewood, CO). Static strength was measured using a Nicholas Manual Muscle Tester (Lafayette Instruments, Lafayette, IN). Dynamic strength measurements were obtained using directional balance reach tests. **Main Outcome Measures:** Peak and total (impulse) frontal and transverse plane knee moments during the loading phase of a single-leg stop-jump task were predicted using linear regression models. The predictor variables were isometric strength measurements (hip extension, abduction, adduction, and external rotation), dynamic strength (directional balance reach test scores in the anterior, medial, and posterior medial directions), and hip control variables (peak and total internal moments in three planes). **Results:** The peak frontal plane knee moments were related to both isometric hip strength ($R^2$=0.26, $P$=0.001) and hip control variables ($R^2$=0.26, $P$=0.001). The total (impulse) frontal plane moment was related to isometric hip strength ($R^2$=0.20, $P$=0.008) and hip control variables ($R^2$=0.47, $P<0.001$). **Conclusions:** Our findings revealed that isometric hip strength and hip moment control variables predicted frontal plane knee moments during a single-leg stop-jump task. However, dynamic strength measurements did not predict frontal or transverse plane knee moments in the current study. Additional research on dynamic strength tests is needed to determine their value in predicting injury. Funded by the NATA Foundation Doctoral Research Grant Program.

# Free Communications, Poster Presentations: Clinical Intervention & Assessment

Friday, June 25, 2010, 8:00AM-12:00PM, Grand Hall, authors present 11:00AM-12:00PM

**Hamstring Strength Measurements In Collegiate Athletes With A History Of A Hamstring Injury**

Doherty JL, Van Lunen BL, Ismaeli ZC, Krzyzanowicz RM, Drouin JM, Oñate JA: Old Dominion University, Norfolk, VA, and Lock Haven University of Pennsylvania, Lock Haven, PA

**Context:** Eccentric hamstring strength(EHS) and hamstring:quadriceps ratios(H:Q) have been proposed to decrease in those who suffer hamstring injuries. **Objective:** To assess EHS and the three types of H:Q(conventional, functional and inverse functional) at two different velocities. **Design:** Experimental single test session. **Setting:** University athletic training room and physical therapy clinic. **Patients or Other Participants:** Forty-two division one and three collegiate athletes (age=20.64±1.51 yrs; height= 175.93±10.94 cm; mass=81.77±18.33 kg) with previous hamstring injury (past 24 months). **Interventions:** The Biodex System 3 (Biodex Medical System, Inc., Shirley, NY) was used to complete a total composite of tests: 1)seated knee flexion Eccentric/Concentric at 60 and 180 deg/sec, 2)seated knee extension Eccentric/Concentric at 60 and 180 deg/sec, and 3)seated knee flexion endurance measurement of 30 reps at 180 deg/sec. Separate Paired-Sample *t* tests were conducted for peak torque per body weight(PT/BW) and total work(TW). Pearson Product Moment Correlations were conducted for H:Q measurements. A 2X2 repeated measures ANOVA was used for endurance comparisons between side and repetition (reps 1-5 vs. reps 26-30). Significance was set *a priori* at $P<.05$. **Main Outcome Measures:** Average TW(Joules) from three trials, average TW over 30 repetitions, PT/BW(Nm/kg) at two speeds(60, 180), three types of H:Q ratio comparisons. **Results:** There was no significant difference between sides for PT/BW EHS at 60°/sec [(t=1.161, p=2.52)(Injured(I)=1.52±.34, Noninjured (NI)=1.59±.37)] or 180°/sec [(t= -1.05, p=0.30)(I=1.60±.41, NI=1.66±.33)]. There was no significant difference between sides for TW EHS at 60°/sec [(t= -0.82, p=0.417)(I=114.11±43.64, NI=118.41 ±41.65)] or 180°/sec [(t= -1.191, p=0.24) (I=848.25 ±40.92, NI=888.85 ±46.79)]. There was no main effect for side($F_{1,41}$=2.19, p=0.147), however there was a main effect for repetitions($F_{1,41}$=72.53, p<0.00) with reps 1-5 producing greater TW(971.68±49.00)than repetitions 26-30(765.41±37.14).There were no interactions between side and repetition($F_{1,41}$=0.54, p=0.467). There was no significant difference between sides for functional H:Q at 60°/sec(t= -.268, p=0.79) or at 180°/sec (t=0.300, p=0.77). There was no significant difference between sides for conventional H:Q at 60ˆ/sec(t= -0.734, p=0.47) or at 180°/sec(t=0.468, p=0.64). There was no significant difference between sides for inverse H:Q at 60°/sec(t= -0.349, p=0.73) or at 180ˆ/sec(t=1.356, p=0.18). There was a strong correlation between functional H:Q at 60°/sec and conventional H:Q at 60°/sec(r=0.91, p=.001), and inverse H:Q at 60°/sec (r=0.66, p=.001), respectively. There was a strong correlation between functional H:Q at 180°/sec and conventional H:Q at 180°/sec(r=0.85, p=.001) and between conventional H:Q at 60°/sec and inverse H:Q at 60°/sec(r=0.84, p=.001). No other correlations were significant. **Conclusions:** There were no significant differences for strength measurements except TW over time. These strength measures depict that the injured side is comparable to the noninjured side when examining values at approximately nine months from injury. Further research should examine these measures immediately upon return-to-play.

**The Effect Of Static And Dynamic Flexibility Protocols On Lower Extremity Range Of Motion**

McCann S, Van Lunen BL, Walker S, Ismaeli ZC, Onate JA: Old Dominion University, Norfolk, VA, and Ball State University, Muncie, IN

**Context:** Increases in lower extremity range of motion (ROM) have been measured over time following static stretching (SS); however comparable information related to dynamic stretching (DS) is unknown. **Objective:** To measure lower extremity ROM over time following similar static and dynamic stretching protocols. **Design:** Experimental two-session repeated measures design. **Setting:** University athletics facility. **Patients or Other Participants:** Forty-seven (18M, 30F) physically active college students [age(yrs)=21.77±2.77, height(cm) =166.60 ±11.70, weight(kg)= 75.08±16.99)] with no current history of injury or surgery to the right leg. **Interventions:** The independent variables were two stretching protocols (static, dynamic) and three assessment times [pre, immediately post (immed), and twenty minutes post (20min)]. Stretching protocols were conducted on different days using a universal goniometer to measure active hip flexion (HFLX), extension (HEXT), and abduction (HABD), knee flexion (KFLX) and extension (KEXT), and ankle dorsiflexion (AD). The static protocol consisted of 11 total stretches, held for thirty seconds per leg with five seconds between legs and fifteen seconds between stretches. The dynamic protocol consisted of 10 total stretches, performed continuously, alternating legs for sixty seconds with thirty seconds rest between stretches. The protocols were matched according to the total stretch time of each muscle. Separate 3 X 2 repeated ANOVAs were used to analyze the change in hip, knee, and ankle ROM. Significance was

set a prori at P<.05. **Main Outcome Measures:** The dependent variables were hip, knee, and ankle ROM measured in degrees. **Results:** There was a difference for HFLX between assessment times [($F_{(2,46)}$=4.875,p=0.012), $HFLX_{pre}$ = 114.88±9.70, $HFLX_{immed}$ =112.48±10.46, $HFLX_{20min}$ =113.53±9.85] with a decrease immediately following stretching (p=0.009). There was no difference for HEXT between times [($F_{(2,46)}$=0.519,*p*=0.599) ($HEXT_{pre}$=23.58±7.88, $HEXT_{immed}$ =23.85±8.57, $HEXT_{20min}$ =23.28 ±8.37] or protocol ($F_{(1,47)}$=1.130,*p*=0.293) ($HEXT_{(DS)}$=24.02±8.32, $HEXT_{(SS)}$ =23.12± 8.23); no difference for HABD between times [($F_{(2,46)}$=1.916,*p*=0.159) ($HABD_{pre}$=32.49 ±8.39, $HABD_{immed}$ =33.55±8.49, $HABD_{20min}$ =32.89±7.84] or protocol [($F_{(1,47)}$=3.163,*p* =0.082) ($HABD_{(DS)}$= 33.80±9.10, $HABD_{(SS)}$ =31.15±7.38)].There was a difference for KFLX between times [($F_{(2,46)}$=3.717,*p*=0.032) ($KFLX_{pre}$=127.98±7.66, $KFLX_{immed}$ =127.86± 8.62, $KFLX_{20min}$ =126.91±8.17]; a difference between protocol for KFLX [($F_{(1,47)}$=3.163 ,*p*=0.082) ($KFLX_{(DS)}$=127.32 ±8.43, $KFLX_{(SS)}$ =127.85± 7.87)]; a difference for KEXT between times [($F_{(2,46)}$=13.364 ,*p*<0.001) ($KEXT_{pre}$=28.0± 14.16, $KEXT_{immed}$ =24.32± 13.65, $KEXT_{20min}$ =26.94±14.31)] with a decrease immediately following stretching (p<0.001) and an increase observed twenty minutes after stretching (p=0.002). There was no difference between protocol for KEXT [($F_{(1,47)}$=1.116,*p*=0.296) ($KEXT_{(DS)}$= 25.80± 13.34, $KEXT_{(SS)}$ =27.04 ±14.74)]. There was a difference for AD between times [($F_{(2,46)}$=9.052,*p*<0.001) ($AD_{pre}$=19.09±4.83, $AD_{immed}$ =20.5±4.94, $AD_{20min}$ =20.13±4.72)] with an increase immediately following stretching(p<0.001) and twenty minutes after stretching (p=0.002). There was no difference between protocol for AD [($F_{(1,47)}$=3.68,*p*= 0.061) ($AD_{(DS)}$=20.35±4.95, $AD_{(SS)}$ =19.59 ±4.71)] **Conclusion**: An acute bout of either stretching protocol is effective for increasing KEXT and AD ROM but the results diminish after twenty minutes. Further research should examine the effectiveness of similar long-term stretching protocols for increasing ROM and the effect of various stretching protocols on the incidence of musculotendinous injuries.

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**Effect Of Body Position On Angle Of Peak Torque During Isokinetic Knee Extension And Flexion Exercise**

Gear WS, Marien NA: University of Minnesota Duluth, Duluth, MN

**Context:** Isokinetic testing is typically performed in a seated position. Assessment in a prone or supine position, however, may better represent functional activities that require contraction of the thigh musculature with the hip in an extended position. **Objective:** The purpose of this study was to examine the effect of body position on angle of peak torque during isokinetic exercise of the knee. **Design:** Repeated measures design. **Setting:** Laboratory setting. **Patients or Other Participants:** 14 (7 male [20.8 ± 1.1 yrs., 91.1 ± 11.9 kg] and 7 female [19.5 ± 1.2 yrs., 64.5 ± 7.1 kg]). **Interventions:** Isokinetic knee strength was assessed in a seated, supine and prone position using the lateral femoral epicondyle to align the axes of rotation of the knee joint with the dynamometer for all conditions. Isokinetic strength was assessed through an angular range of motion of 0-120º of knee flexion at angular velocities of 60, 180 and 300 deg·s$^{-1}$ for 10 repetitions. **Main Outcome Measures:** Angle of peak torque for concentric isokinetic knee extension and flexion was assessed at angular velocities of 60, 180 and 300º·s$^{-1}$ for 10 repetitions. One-way ANOVAs for angle of peak torque for the quadriceps and hamstring muscles against position were used for statistical analysis. Differences at the .05 level were followed by Tukey's HSD to determine which means differed. **Results:** Significant differences were found for the quadriceps at angular velocities of 60º·s$^{-1}$ (seated = 67.43 ± 6.89º, supine = 60.00 ± 6.63º, and prone = 79.36 ± 13.07º [$F_{2,39}$ = 15.266, p < 0.000]), 180º·s$^{-1}$ (seated = 59.43 ± 6.41º, supine = 54.50 ± 5.64º, and prone = 78.08 ± 14.79º [$F_{2,39}$ = 21.617, p < 0.000]) and 300º·s$^{-1}$ (seated = 65.29 ± 11.98º, supine = 56.07 ± 17.39º, and prone = 80.21 ± 27.72º [$F_{2,39}$ = 5.134, p < 0.01]). The prone position was significantly different from the seated position for angular velocities of 60º·s$^{-1}$ and 180º·s$^{-1}$ (p < .005, p < 0.000 respectively) and from the supine position for angular velocities of 60º·s$^{-1}$, 180º·s$^{-1}$, and 300º·s$^{-1}$ (p < 0.000, p < 0.000, and p < 0.008 respectively). Significant difference for body position was found for the hamstrings at 180º·s$^{-1}$ (seated = 29.35 ± 6.31º, supine = 21 ± 5.17º, and prone = 20.00 ± 7.22º [$F_{2,39}$ = 8.927, p < 0.001]). The seated position was significantly different from the supine (p < .004) and prone ( p < .001) position. **Conclusions:** Results from this study appear to indicate that body position is a factor in angle of peak torque for the quadriceps at angular velocities of 60, 180 and 300º·s$^{-1}$. Body position only had an effect on hamstring angle of peak torque at an angular velocity of 180º·s$^{-1}$.

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**Comparison Of Lower Extremity Isometric Strength Measures Between The Dominant And Non-Dominant Limb In NCAA Soccer Athletes**

Ismaeli ZC, Onate JA, Kollock RO, Van Lunen BL: Old Dominion University, Norfolk, VA

**Context:** Most soccer athletes have a dominant limb used for sport-specific activities such as kicking. This unilateral dominance can create asymmetry between limb strength and performance measures. Contra-lateral strength imbalances assessed using isotonic and/or isokinetic measures have been suggested to increase the risk of lower extremity injury. Extensive research has shown no difference in strength values between limb dominance when using these measures. Isometric strength is an efficient and reliable assessment measurement, however, limited research has assessed effects of dominance for isometric strength measures in a sport-specific population. **Objective:** To compare isometric strength measures between the dominant(D) and non-dominant(ND) limb in NCAA collegiate soccer athletes. **Design:** Quasi-experimental. **Setting:** Research laboratory and athletic training clinic. **Patients or Other Participants:** A sample of convenience of 54 male (19.49 ± 1.36 years, 181 ± 6.29 cm, 75.82 ± 7.70 kg) and 50 female (19.08 ± 1.10 years, 168 ± 6.30 cm, 62.38 ± 7.53 kg) Division I collegiate soccer athletes. All participants were currently cleared for athletic participation at the time of the study. Dominance was determined by the limb used to kick a ball the hardest. **Interventions:** The independent variable was side (dominant vs. non-dominant). Paired t-tests were used to assess differences between limbs for all dependent variables. Bonferroni adjustment was conducted due to multiple comparisons and the alpha level was set at *P*<.00625. **Main Outcome Measures:** A portable fixed dynamometer, BTE Evaluator, (Hanover MD) was used to measure lower extremity maximal voluntary isometric contractions for eight positions: [standing Hip Flexion (HF), Hip Extension (HE), Hip Abduction (HAdd), Hip Abduction (HAbd), and seated Knee Flexion (KF), Knee Extension (KE), Hip External Rotation (HER), Hip Internal Rotation (HIR)]. The average of three trials for each strength measurement was used for analysis. The dependent variable was the isometric maximal voluntary contraction (N/m) for each position. **Results:** There was a statistically significant difference between limb for HAdd (p=.004, t= 2.94), KF (p=.002, t= -3.11), KE (p<0.001, t=15.86) with the dominant limb HAdd (D=36.74±12.50), KF (D=50.35

±15.21), KE (D=80.33±24.62) producing greater strength than non-dominant limb HAdd(ND=34.43±10.76), KF(ND= 48.12± 15.20), and KE(ND=51.02±17.99). There was no significant difference between limb for HE [(p=.201, t= -1.287) D(31.10±11.59), ND(31.96±11.17)], HF[(p =.337, t= -.964) D(35.17±9.91), ND(34.43 ±10.75)], HIR [(p=.120, t=1.567) D(28.90 ±9.12), ND(30.03±9.82)], HER [(p=.275, t= -1.097) D(29.30±8.78), ND(28.62±9.04)], or HAbd [(p=.432, t= -.789) D(28.19±8.93), ND ( 27.78±8.44)]. **Conclusion:** Our results indicate that there are some strength differences between dominant and non-dominant limbs for soccer athletes. Further studies should investigate strength related issues related to strength ratios, effects of previous history of lower extremity injury, sport-specific activities, and criteria to determine dominance in different sports.

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**Acute Effects Of Pre-Practice Stretching Protocols On Hamstring Flexibility In Collegiate Football Players**

Smith SC, Conger KB, Greisiger KE, Stevens SW: The University of Findlay, Findlay, OH

**Context:** It has been suggested that a lack of flexibility may predispose an athlete to injury and significantly affect performance. There are several stretching techniques used clinically to increase joint range of motion with proprioceptive neuromuscular facilitation (PNF) becoming the most common. **Objective:** To determine if unassisted PNF stretching with a Jump Stretch Flex Band® is as effective as assisted PNF stretching with an athletic training student to increase hamstring flexibility. **Design:** Randomized crossover clinical trial. **Setting:** Athletic Training Research Laboratory **Patients or Other Participants:** Twenty-two, healthy male collegiate football athletes, (age:20±1.4 yrs, ht:1.823±.07 m, wt:92.39±13.3 kg). Subject criteria included: no lower extremity or back injury within the last six months requiring medical attention, no known condition affecting flexibility, no suspected fractures on the right lower extremity, no current participation in a formal rehabilitation plan for the right lower extremity and no limited participation in normal physical activity. **Interventions:** The independent variable was flexibility training consisting of three testing conditions: assisted PNF stretching with an athletic training student (1), unassisted PNF stretching with a Jump Stretch Flex Band® (2), and control with no stretching protocol (3). Each subject completed all 3 conditions with a minimum of 72 hours separating each session. Treatment order was determined using a balanced latin square. Conditions 1 and 2 followed a specific stretching protocol while condition 3 rested quietly. A gain score was calculated for each condition to be used for analysis. The data were analyzed using a 2X3 repeated measures ANOVA followed by pairwise comparisons since we were interested in within subjects differences. The p-value was set at 0.05. **Main Outcome Measures:** Hamstring flexibility was measured using the Active Knee Extension Test (AKE) before and after each session's protocol. The AKE is recognized as a valid and reliable measure of hamstring flexibility. All measurements were taken by one researcher using a 12" universal goniometer. Intraday reliability for each condition $ICC_{(3,k)}$ ranged from .987-.996 and interday reliability $ICC_{(3,k)}$=.993 were excellent. **Results:** There was a difference in hamstring flexibility $F_{(2,42)}$= 8.54, p=.001, $\eta^2$=.289. After pairwise comparison it was determined that the differences were between the two treatment conditions and control. Unassisted PNF self stretching with the Jump Stretch Flex Band® increased 2.77° (M=3.30, ± 2.94°, p=.002) and PNF assisted stretching increased 2.55° (M=3.08, ± 2.15°, p<.001) compared to control (M=.53±1.5°). The difference between PNF assisted and PNF self stretching was not significant at -.23°, p=.791. **Conclusions:** Our data supports the idea that there is no difference between the two types of PNF stretching protocols to increase hamstring flexibility; therefore, in season collegiate football players can achieve flexibility gains with either PNF stretching with an athletic training student or using a Jump Stretch Flex Band®.

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**Relationships Among Static And Dynamic Measurements Of Hip And Trunk Muscle Strength And Endurance**

Bazett-Jones DM, Joshi M, SE Cashin, Cobb SC, Earl JE: University of Wisconsin-Milwaukee, Milwaukee, WI

**Context:** Poor hip strength and core endurance have been associated with knee injury; however, hip endurance and core strength have not been analyzed. Dynamic measures of hip and core strength and endurance may be more applicable to movement than previously used static measures. **Objective:** To evaluate the relationship between static and dynamic tests of muscle strength and muscle endurance on both the hip and core musculature. **Design:** Multi-session, cross-sectional. **Setting:** Neuromechanics Laboratory. **Patients or Other Participants:** 27 college-aged participants (16 men, 11 women; age=24.8±5.9, mass=80.0±16.8 kg, height=1.77±0.09 m) volunteered to participate. **Interventions:** Participants attended four testing sessions during which static and dynamic measures of hip and core strength and endurance were taken. The static test for muscle strength was a maximal voluntary isometric contraction (MVIC), whereas the static test for muscle endurance was a timed hold test (THT; body part held in position for maximal time). The MVIC was measured with a hand-held dynamometer secured to a non-elastic strap, recorded in kg (max of 3 trials), and body mass normalized. Measures of dynamic strength and endurance included one-repetition maximums (1RM) and repetitions until failure (RTF). The 1RM was normalized to body mass and the RTF was performed at 30 reps per minute. Tests were performed on the trunk flexors (TF), trunk extensors (TE), dominant (DLC) and non-dominant lateral core (NDLC), hip lateral (HLR) and medial rotators (HMR), adductors (ADD), abductors (ABD), seated hip flexors (SHF), prone hip flexors (PHF), hip extension with a straight leg (SLE) and with a bent knee (BKE). **Main Outcome Measures:** Dependent variables included normalized MVIC (%BW), 1RM (%BW), RTF (number of reps), and THT (seconds) for each of the 12 tests. Pearson correlations were used for the statistical analysis to investigate the relationship between static, dynamic, strength, and endurance measures, with an alpha level of p<0.05. **Results:** The relationships between measures of strength (r=0.378-0.821, p<0.001-0.057) and measures of endurance (r=0.339-0.663, p<0.001-0.097) were moderate to strong, with the exception of ADD endurance (r=0.139, p=0.580). Significant correlations were found for 11 of 12 strength measures and 9 of 12 endurance measures, though SHF (p=0.097) and ABD (p=0.092) approached significance for endurance. Only 3 of 12 measures were significant for static and dynamic tests demonstrating weaker relationships between both static (r=0.024-0.679, p<0.001-0.909) and dynamic (r=0.006-0.643, p<0.001-0.977) measures of strength and endurance. **Conclusions:** Static and dynamic measures of strength (MVIC vs. 1RM) seem to have strong agreement, as do endurance measures (RTF vs. THT). Poor agreement was found between static (MVIC vs. THT) and dynamic (1RM vs. RTF) tests. When measuring hip and core strength and endurance, clinicians can feel confident that static measures of strength and endurance, which are easier to perform, provide similar information.

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**Comparison Of Measurement Techniques In The Assessment Of Hip Flexion Angle**

Ferro JE, Snyder AR, Kingma J: College of the Holy Cross, Worcester, MA; A.T. Still University, Post-Professional Athletic Training Program, Mesa, AZ; Indiana University, Athletic Training Program, Bloomington, IN

**Context:** Clinicians and researchers use a variety of techniques including patient-reported end-feel (PRE) and clinician-assessed end-feel (CAE) to evaluate hip flexion angle. However, there is no uniform or standardized recommendation indicating the appropriate or most reliable technique. As a result, there is a lack of methodological consistency in clinical practice and in research investigations of flexibility, making it difficult to identify best practice and to compare studies. **Objective:** To compare measurements of terminal hip flexion angle using PRE and CAE techniques. **Design:** Randomized cross-over design. **Setting:** Collegiate athletic training facility. **Patients or Other Participants:** Twenty-five physically active males (21.8±4.7 yrs, 108.8±8.1 cm, and 80.1±16.7 kg) without low back or lower-extremity injury during the previous 6 months participated in the study. **Interventions:** The independent variables were condition (PRE and CAE) and limb (Right and Left). Participants completed the PRE and CAE conditions on both limbs in a randomized order. Participants were prepared for the measurements of hip flexion angle by placing stickers marked with an X on the anatomical location of the greater trochanters and the lateral femoral epicondyles of their femurs. To evaluate terminal hip flexion angle, the investigator moved the limb into terminal hip flexion, passively, using cues provided either from patient (PRE) feedback or clinician (CAE) skill. Two trials were performed for each condition and photographs were taken of the terminal angle for all trials. The angle tool of the National Institutes of Health (NIH) ImageJ (Bethesda, Maryland) software program was used to analyze the photographs of each hip flexion angle. Previous research reports the intertester and intratester reliability of the ImageJ software to be .97 and .99, respectively. The intratester reliability of the investigator in this study ranged from .82-.99. Paired t-tests were used to determine if significant differences existed between the PRE and CAE hip flexion measurement techniques on either the right or left limbs. Data are reported as mean±SD. Significance was accepted at $p<.05$. **Main Outcome Measures:** The dependent variable was terminal hip flexion angle. **Results:** There was no significant difference between the PRE and CAE measurements of hip flexion angle on the right limb (PRE=84.1±14.6; CAE=83.2±14.5, $t_{24}= .76$, $p=.45$). Similarly, there was no significant difference between the PRE and CAE measurements of hip flexion angle on the left limb (PRE=81.7±16.0; CAE=78.9±13.4, $t_{24}= 1.66$, $p=.11$). **Conclusions:** Our findings revealed no difference between the use of PRE and CAE techniques when determining passive terminal hip flexion angle. These results suggest that clinicians and researchers could use either technique to measure terminal hip flexion angle and that comparison of studies using either technique may be appropriate. Future research should evaluate the PRE and CAE methods for the assessment of other joint angle measurements.

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**Peak Maximum Voluntary Isometric Activation Levels Of The Gluteus Medius Muscle Performed In Three Different Testing Positions**

Inoue N, Dwyer MK, Mattacola CG, Stafford KM: University of Kentucky, Lexington, KY

**Context:** Maximum voluntary isometric contraction (MVIC) testing for the gluteus medius muscle has traditionally been collected during side-lying resisted hip abduction. However, recent studies have reported greater muscle activation levels for the gluteus medius muscle during weight-bearing muscle contractions when compared to side-lying hip abduction. Therefore, performing MVIC testing for the gluteus medius muscle in a weight-bearing position may provide a better representation of true maximal muscle activation levels than those collected in a side-lying position. **Objective:** To compare peak EMG amplitudes for the gluteus medius muscle between 3 different testing positions (Side-lying hip abduction (SL), standing non-weight-bearing hip abduction (NWB), and standing weight-bearing hip abduction (WB)). **Design:** Cross-sectional study. **Setting:** Research laboratory. **Patients or Other Participants:** 28 healthy subjects (age: 41.5 ± 13.9y, weight: 74.8 ± 14.7kg, height: 172.2 ± 9.6cm) participated in this study. Inclusion criteria were no history of major lower extremity injury or surgery. **Interventions:** EMG data were collected using the Myopac System (Run Technologies, Mission Viejo, CA). All EMG data were stored and analyzed using Datapac 2K2. Electrodes were placed on the dominant limb gluteus medius muscle for each subject. Dominance was defined as the limb with which a subject would use to kick a ball. All subjects performed three 3-second MVIC's for each of the three testing positions (SL, NWB, WB). Order of testing was randomized. **Main Outcome Measures:** The dependent variable was peak EMG amplitude of the gluteus medius muscle. The independent variable was testing position (SL, NWB, WB). A one-way analysis of variance (ANOVA) was performed to detect differences between testing positions. Level of significance was set *a priori* at $p \leq 0.05$. **Results:** There was no significant differences in peak EMG amplitudes between any of the testing positions (SL: 0.1434 ± 0.10V, NWB: 0.1507 ± 0.11V, WB: 0.1573 ± 0.10V; $p = 0.885$). **Conclusions:** Our results demonstrated that peak EMG amplitudes for the gluteus medius muscle do not differ when MVIC testing was performed in either of the testing positions. Therefore, it is appropriate to collect MVIC data for the gluteus medius muscle in either a side-lying or weight-bearing position.

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**Surface Electromyography Of The Abductor Hallucis And Anterior Tibialis Muscles During The Intrinsic Foot Muscle Test**

Sibilsky E, Sauer LD, Hart JM, Saliba SA, Hertel J: University of Virginia, Charlottesville, VA

**Context**: The intrinsic foot muscle test (IFMT) is a functional evaluation tool that assesses activation of the intrinsic foot muscles (IFM). For the test, patients are asked to maintain a neutral foot position in single-limb stance while the clinician evaluates the patient's ability to maintain the foot position without over-activity of the extrinsic foot muscles (EFM) or unsteadiness of the arch height. Performance on the IFMT is subjectively graded as 'poor', 'fair' or 'satisfactory' and has not been evaluated with an objective assessment of muscle activation to determine the validity of the current classification system. An objective measurement of the IFM and EFM activity via surface electromyography (sEMG) is one way to evaluate the activation of the muscle groups during the test. **Objective**: To evaluate activation of the IFM and EFM with sEMG and compare to the grading system of poor, fair and satisfactory performance currently used for assessment. **Design**: Descriptive laboratory study. **Setting**: Laboratory. **Patients or Other Participants**: Fifty-eight healthy subjects without lower extremity injuries in the past six weeks or peripheral neuropathy participated (29 males, 29 females; 22.8±6.0yrs, 75.8±17.0kg, 174.8± 10.5cm). **Intervention(s)**: All subjects performed the IFMT while sEMG simultaneously recorded activation of anterior tibialis (AT) and abductor hallucis (AbH) muscles. AT activation represented EFM contribution and

AbH represented the IFM. IFMT performance was graded for all subjects as poor, fair or satisfactory. **Main Outcome Measures**: Muscle activation as normalized mean root mean square (mRMS) for the AT and AbH muscles during the 30-second test. Activation during the exercise was normalized to a quiet-standing trial prior to testing and reported as %-activation of quiet standing. Differences were assessed according to performance on the IFMT with Kruskal-Wallis non-parametric test and reported as the median (interquartile ranges [IQR]: 25$^{th}$, 75$^{th}$). The alpha level was set at $p<0.05$. **Results**: For AbH activation, subjects scoring 'satisfactory' on the IFMT had a median mRMS activation of 5.0% [-5.4,15.4], those scoring 'fair' demonstrated an activation of 10.8% [-9.2,30.7] and those scoring 'poor' demonstrated an activation of 8.6% [1.33,16.0]. There was not a significant association between AbH activation and IFMT performance (p= 0.166). For AT activation, subjects scoring 'satisfactory' on the test demonstrated a median activation of 3.5% [-6.5,13.6], those scoring 'fair' demonstrated an activation of 15.2% -23.2,53.7] those scoring 'poor' on the IFMT had an activation of 2.5% [-17.8,22.9]. There was not a significant association between AT activation and IFMT performance (p= 0.061). **Conclusions**: This is the first study to evaluate function of the IFM and EFM during the IFMT with sEMG. The subjective grading of the IFMT was not significantly associated with the AbH and AT muscle activation. The grading system for the IFMT may not reflect AbH activation.

**Whole Body Immersion In Warm Water Does Ameliorate DOMS Symptoms Following Eccentric Exercise**

Taniguchi Y, Nethery V, D'Acquisto L, Burnham T: Central Washington University, Ellensburg, WA

**Context:** Few effective treatment or prevention strategies for delayed onset muscle soreness (DOMS) have been identified. However, a decrease in DOMS was noted when therapeutic massage was administration 2-3 hours following eccentric exercise. Common elements purported for both whole body immersion (WBI) in warm water and therapeutic massage include elevated extra-vascular pressure, facilitated lymphatic drainage and venous return, and some mitigation of muscular pain. **Objective:** The purpose of this study was to investigate the impact of exposure to WBI in warm water (40°C) on DOMS symptoms when administered 2 hours following eccentrically induced muscle trauma. **Design:** A counter-balanced, crossover, within subjects design was utilized. Two-way repeated-measure ANOVA's (Bonferroni post-hoc) assessed the significance of differences observed. **Setting:** The DOMS induction, post DOMS treatment and data acquisition procedures were conducted in the exercise science laboratory and athletic training treatment facilities. **Participants:** Twelve healthy males (mean (SE) age: 23 (3) yrs, height: 179 (9) cm, mass: 83 (13) kg, leg length: 86.6 ± 4.7 cm) with no recent history of lower body weight training and major lower extremity injury, volunteered for the study. **Interventions:** Subjects performed a stepping protocol, wearing a weighted vest (6% of body mass) on a bench (height: 65% of leg length) designed to induce DOMS in the quadriceps and calf muscle groups of one limb by raising and lowering on the same leg. Two hours following the DOMS inducing exercise, they either rested (non-treatment (NT) trial) or received WBI for 20 minutes. Two weeks later, the same exercise regimen was repeated on the contra-lateral limb with a crossover of the treatment. **Main Outcome Measures:** Serum creatine kinase (CK), limb circumferences, muscle tenderness (algometer: 2.7kg/cm$^2$), and active muscle soreness (quadriceps: sit-to-stand, calf: dorsi-plantar flexion) were measured before inducing DOMS and at 2.5, 24, 48, 72, and 96 hours post trials. **Results:** CK levels rose substantially by 24 hours in both trials (WBI: 292.1 ± 62.7 IU/L, NT: 296.3 ± 28.6 IU/L) and, while no interaction was evident (trials x time $P = 0.15$)), a somewhat steeper decline beyond 24h was observed in CK following WBI. WBI resulted in lower overall tenderness in both the quadriceps ($P = 0.07$) and calf musculature ($P = 0.08$) and lower active soreness during sit-to-stand activity at 48 hours ($P = 0.08$) and during dorsi-plantar flexion at 24 ($P = 0.01$) and 48 hours ($P = 0.03$). **Conclusions:** WBI in warm water 2 hours following DOMS inducing exercise did ameliorate several symptoms typically associated with eccentrically induced muscle trauma to a greater extent than no treatment. Funded by the NATA Foundation Master's Research Grant Program.

## Free Communications, Poster Presentations: Functional Screening & Testing

Friday, June 25, 2010, 8:00AM-12:00PM, Grand Hall, authors present 11:00AM-12:00PM

**Minimum Detectable Difference Between Legs And Learning Effects Of Three Functional Tests**

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**Context:** Clinicians have traditionally compared the uninvolved limb to the involved limb to determine the level of impairment and readiness to return to sport. **Objective:** To determine the minimum detectable difference ($MDD_{95\%}$) between legs and the learning effect between days and trials on 3 functional tests. **Design:** A 3x3x2 (day, trial, leg) counterbalanced repeated measures. **Setting:** Research laboratory. **Participants:** Twenty four (12 males, 12 females) healthy subjects (age = 22.3±1.7 yrs, height = 171.4±9.2 cm, mass = 77.2±23.1 kg) with no history of lower extremity injury within the past 12 months. **Interventions:** All subjects performed 3 trials of vertical jump (VJ), triple hop (TH) and timed crossover (TC) on each leg for 3 consecutive days. Separate 3x3x2 repeated measures ANOVAs were used to determine the effects of day, trial and leg on VJ height, TH distance and TC time with an $\alpha$=0.05 and Tukey post-hoc. **Main Outcome Measures:** Single leg: vertical jump (cm), triple hop distance (cm), timed crossover (s). **Results:** There were no significant day x trial x leg, leg x day, leg x day interactions for VJ, TH and TC (range p=.12 to .853). A significant learning effect (p=.04) was found for VJ from day 1 (33.83±10.55 cm) to day 3 (35.28±9.87 cm). VJ significantly improved (p=.000) with each trial, trial 1 (34.07±10.00 cm), trial 2 (34.64±10.02 cm), and trial 3 (35.22±10.24 cm). A significant learning effect (p=.008) was found for TH from day 1 (492.55±129.75 cm) to day 3 (505.81±124.11 cm). TH trials were significantly different (p=.000) with trials 1 (494.44±125.63 cm) and 2 (500.31±126.80 cm) different from trial 3 (503.48±125.79 cm). A significant (p=.00) trial x day effect was found for TH, day 1, trial 1 (482.64±129.69 cm), trial 2 (492.02±131.77cm) and trial 3 (501.97

±129.73 cm) were different from each other. A significant learning effect (p=.000) was found for TC: day 1 (18.19±8.34 s), day 2 (14.87±6.84 s), and day 3 (13.02±4.88 s). TC trials were significantly different (p=.000) with trials 1 (15.87±7.59 s) and 2 (15.59±7.36 s) different from trial 3 (14.61±6.43 s). A significant (p=.001) trial x day effect was found for TC. On day 1, trials 1 (19.24±9.08 s) and 2 (18.42±8.35 s) were different from trial 3 (16.90±7.52 s). On day 2, trial 1 (15.24±6.81 s) was different from trial 3 (14.26±6.31 s). The between leg $MDD_{95\%}$ for VJ by day was 2.84, 3.16 and 3.07 cm. The between leg $MDD_{95\%}$ for TH by day was 9.05, 7.56 and 7.47 cm. The between leg $MDD_{95\%}$ for TC by day was 3.07, 2.76 and 2.16 s. **Conclusions:** When evaluating impairment following injury and improvement following rehabilitation, clinicians should be cognizant of the $MDD_{95\%}$ between healthy limbs.

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**Test Re-Test Reliability Of The UNC Functional Performance Test**

Hash NR, Sandrey MA, Bulger S, Erickson J: West Virginia University, Morgantown, WV, and Lipscomb University, Nashville, TN

**Context**: Functional screening tests for football may provide valuable information for return to play decisions and assessment of usefulness is important. The UNC Functional Performance Test has been used as criteria for return to play but reliability for this test is unknown. **Objective**: To establish reliability for the UNC Functional Performance Test (UNCFPT), a battery of functional tests. **Design***:* A prospective test re-test design. **Setting***:* A Division II Mid-Atlantic University. **Patients or Other Participants**: A total of 47 participants from a D-II football program (age=19.77±1.43 yrs, mass=101.38±20.08 kg, height=184.45±7.62 cm) volunteered. All were current players encompassing a variety of position groups and were free of lower extremity injury within the last six months. **Interventions**: The participants were asked to complete the UNC Functional Performance Test of which included the shuffle box drill, figure eight test, single leg (SL) hop test for time, carioca test, and SL triple hop for distance. Each test was completed three times with a 30 second rest between trials and each successive test. 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 ($ICC_{2,1}$) was used for test-retest reliability, with Standard Error of Measurement (SEM) and Methodological Error. **Main Outcomes Measures**: Three maximal attempts with the best time recorded in seconds for shuffle box drill, figure eight test, SL hop test for time, and carioca test, except for the best SL triple jump which was recorded in inches. **Results**: The SL triple hop had the highest ICC ($ICC_{2,1}$=.956, SEM=5.97 for the right side and SEM=5.89 for the left side) followed by shuffle box drill ($ICC_{2,1}$=.933, SEM=.202 sec), carioca ($ICC_{2,1}$=.930, SEM=.173 sec) and the figure eight ($ICC_{2,1}$=.892, SEM=.329 sec). The lowest ICC was for the SL hop test ($ICC_{2,1}$=.873, SEM=.211 sec). Highest SEM results were for the figure 8 (SEM=.329 sec) and the R side SL Triple Hop (SEM=5.97 sec). Methodological error ranged from .011% to 6.56%. Due to different forms of measure (time and distance); the actual ICC and SEM could not be calculated for the UNCFPT. However, it can be speculated that the UNCFPT as a whole would have an approximate $ICC_{2,1}$ of .9168 (95% CI) and a SEM between .173 and 5.975. **Conclusion**: The UNC Functional Performance Test is a reliable objective measure as a lower extremity functional battery of tests when used as described. Further research needs to be conducted on the validity of the UNC Functional Performance Test since excellent reliability was established for the individual components.

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**Sport-Level And Sex Comparisons Of Functional Movement Screen Scores**

Webster KA, Cuson MJ, Brigle JR, Wieczorkowski MP, Gribble PA: University of Toledo, Toledo, OH

**Context:** The Functional Movement Screen (FMS) is a series of seven tests used to assess bilateral strength and range of motion deficits in active individuals which produces an overall score out of 21 points. This tool has been used previously to predict injury in professional football players, but comparisons of performance on the FMS between level of athlete and sex have not been explored in current research. **Objective:** To determine if differences in FMS scores exist between sport-level and sex in basketball players. **Design:** Descriptive cohort study. **Setting:** High school and university athletic training rooms. **Patients or Other Participants:** Eighty-eight participants including 28 college (14M/14F;19.4±1.0yrs, 184.2±7.5cm, 81.8±11.0kg) and 60 high school (29M/31F; 15.7±1.2yrs, 176.0± 8.5cm, 65.4±11.3kg) basketball players volunteered for the study. **Interventions:** Basketball players from two high schools and one Division I university were assessed and scored using the FMS prior to the start of the competitive basketball season. Independent variables included sex (Male, Female) and level (High School, College). A two-way analysis of variance was used to analyze the effects of both sex and level on overall outcome scores. Standardized effect sizes (*d)* and 95% confidence intervals were calculated to measure the magnitude of the effects. **Main Outcome Measures:** Three attempts were made at each of the seven tests with the lowest score recorded. Each test was scored from 0-3 and combined for a highest possible score of 21 with higher scores indicating greater performance. This total FMS score was the dependent variable. **Results:** Main effects for sex demonstrated statistical significance ($F_{1,86}$=4.39, *P*=.039; *d*=0.43, 95% CI=0.01 to 0.85) with males scoring 14.5±2.34 and females scoring 15.5±2.23. There was no significant main effect on level ($F_{1,86}$=1.18, *P*=0.28; *d*=0.24, 95% CI=-0.22 to 0.68) with college basketball players scoring 15.4±2.41 and high school basketball players scoring 14.9±2.29. There was no significant interaction between sex and sport level ($F_{1,86}$=1.89, *P*=0.14). **Conclusions:** Although there was a significant difference between men's and women's scores on the FMS, regardless of level, these scores were only different by one point and may not be clinically impactful as evidenced by a small effect size. Additionally, there do not appear to be differences in the pre-season performances between high school or college basketball players on this screening tool. Therefore, the FMS does not appear to be bias towards sex or level of athlete and therefore can be used to assess functional movement in both men and women and across sport-level.

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**Differences In Jump-Landing Biomechanics In Individuals Demonstrating Faulty Movement Patterns On The Landing Error Scoring System**

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**Context:** Faulty movement patterns are hypothesized risk factors for non-contact ACL injury. Clinical movement assessment is a key aspect of ACL injury screening and prevention programs, as laboratory based motion analysis testing are not clinically feasible. The Landing Error Scoring System (LESS) is a clinical assessment of jump-landing movement; however, the validity

of individual LESS items has yet to be established. **Objective:** To compare lower extremity biomechanics between individuals scoring positive and negative on individual LESS items. **Design:** Cross-sectional. **Setting:** Research laboratory. **Patients or Other Participants:** 2,662 healthy, physically active participants (males=1,602; females=1060; age=18.6±0.6 yrs, ht= 173.5±9.2 cm, wt=71.9±12.9 kg). **Interventions:** Participants performed a jump-landing task (3-trials) by jumping from a 30-cm high box, landing at a 50% distance of participants' height, followed by an immediate vertical jump. Kinematics and kinetics were measured using an electromagnetic motion analysis system and force plate. Video cameras recorded frontal and sagittal plane views of jump-landings. The videos were scored by trained raters using the LESS. The LESS consists of 17-items in which movement patterns are evaluated using a binary system (0=no error, 1=error). **Main Outcome Measures:** Three-dimensional initial contact (IC) and peak (PK) hip and knee joint angles were averaged across 3-trials. Peak anterior tibial shear force (ATSF) and vertical ground reaction force (VGRF) were also identified and normalized to body weight. Participants were grouped as being either negative (NE) or positive (E) error for each individual LESS item based on their score for at least two of three trials. Separate ANOVAs compared select biomechanical variables between groups ($\alpha$0.05). **Results:** All LESS items scored at IC were different between groups: knee flexion (knee flexion θ: NE=19.1±7.3, E=15.7±7.2, $P$<0.001), hip flexion (hip flexion θ: NE=-28.6±10.2, E= -22.8±10.9, $P$=0.003), trunk flexion (hip flexion: NE=-30.0±10.0, E=-24.5±9.5, $P$< 0.001), knee valgus (knee valgus θ: NE=0.7 ±5.4, E=0.1±5.0, $P$=0.04), stance width wide (hip abduction θ: NE=-10.1±6.4, E=-11.9± 6.6, $P$<.001), and stance width narrow (hip abduction θ: NE= -10.5±6.4, E=-8.9 ±6.5, $P$ < .001). All LESS items scored at maximum were different between groups: knee flexion (knee flexion θ: NE=81.0 ±14.0, E= 67.1±11.5, $P$<0.001), hip flexion (hip flexion θ: NE =-81.0±14.0, E=-67.1±11.5, $P$<0.001), trunk flexion (hip flexion : NE=-74.4±16.6, E= -55.6±17.0, $P$<0.001), knee valgus (knee valgus θ: NE=-10.3±7.8, E=-14.6±8.0, $P$<0.001), toe out (hip rotation θ: NE=-14.1±8.6, E=-16.8±8.7, $P$<.001; tibia rotation θ: NE=-6.5±7.7, E=-8.0±6.8, $P$<.001), and toe in (hip rotation θ: NE=4.4±9.0, E=10.1±7.4, $P$<.001; tibia rotation θ: NE=15.1±7.9, E=17.7±8.3, $P$<.001). VGRF and ATSF were greater in those scoring positive on the following LESS items ($P$<0.05): foot contact symmetry (VGRF only), toe to heel landing, and stiff landing. **Conclusions:** The LESS is a biomechanically valid clinical assessment tool for identifying movement impairments. *(Funded by the NIAMS Division of the National Institutes of Health, #R01-AR050461001)*

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**Validation Of The Army 101st Airborne Division (Air Assault) Eagle Tactical Athlete Program**

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**Context:** Optimal physical readiness of the Army soldier is paramount to tactical operations, performance, and injury prevention. Current research has identified several suboptimal characteristics which necessitate refined physical training. **Objective:** To validate the Eagle Tactical Athlete Program (ETAP) to modify suboptimal strength, performance, and Army Physical Fitness Test variables. **Design:** A randomized controlled trial. **Setting:** A University-operated, military human performance research laboratory. **Patients or Other Participants:** A total of 57 soldiers of the 101st Airborne Division (Air Assault) participated (Experimental- N: 30, age: 25.0 ± 5.2 years, height: 173.4 ± 8.3 cm, mass: 76.6± 11.3 kg, Control- N: 27, age: 25.0 ± 5.8 years, height: 175.6 ± 8.5 cm, mass: 76.5 ± 11.6 kg) participated. **Interventions:** Pre- and post-test measurements were captured for strength, performance, and Army Physical Fitness Test variables. Subjects were randomly assigned to an experimental or control group. The experimental group performed an eight week clinical trial of ETAP, which was based on the results from 21 months of laboratory data collected on soldiers of the 101st Airborne Division. ETAP followed a sports medicine periodized training model and included specific modalities designed to improve athleticism. The periodized training program was also developed to specifically address and maximize each athletic and skill-related performance component to ensure the tactical athletes are a viable force for deployment into the demands of the current conflict. The control group performed standard physical training according to FM 3-22.20. This trial was designed to induce adaptations in variables known to contribute to injury and limit performance. **Main Outcome Measures:** Knee, shoulder, and torso strength, body fat, anaerobic power and capacity, performance tests, and the Army Physical Fitness Test. Two way repeated measures ANOVA tests were used to analyze the dependent variables. **Results:** Compared to the control group, soldiers performing ETAP demonstrated significant improvements ($p < 0.05$) in knee extension strength (pre: 236.0 ± 48.9 %BW, post: 244.1 ± 42.3 %BW), torso strength (pre: 128.5 ± 33.5 %BW, post: 137.6 ± 27.4 %BW), 2-minute sit-ups (pre: 58.9 ± 13.3 repetitions, post: 68.0 ± 10.0 repetitions), 2-mile run (pre: 16.6 ± 2.4 minutes, post: 15.4 ± 2.0 minutes), agility (pre: 5.37 ± 0.45 seconds, post: 5.25 ± 0.38 seconds), 300 yard shuttle (pre: 69.2 ± 6.22 seconds, post: 66.8 ± 6.3 seconds), and anaerobic power (pre: 11.9 ± 2.3 w/kg, post: 13.9 ± 2.4 w/kg). **Conclusions:** Soldiers performing ETAP demonstrated significant improvements in variables that are vital to physical readiness, improving the athleticism of the soldier, and reducing the likelihood of musculoskeletal injury. The observed training adaptations should have long-term implications to improve physical readiness of the soldier when ETAP is periodized across a 10-12 month pre-deployment cycle.

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**Reliability Assessment Of Functional Screening Tests**

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**Context:** The use of the Functional Movement Screen (FMS) to detect limitations in flexibility, mobility, and stability has increased by clinicians. This is largely due to the functionality of the movements that are assessed within the battery and the ease of administering the test. However, minimal information regarding the reliability of this assessment tool is available. **Objective:** To examine the inter-session and inter-rater reliability of the FMS. **Design:** Test-retest reliability study. **Setting:** University Sports Medicine Research Laboratory. **Patients or Other Participants:** 12 males and 7 female (age: 25.15 ±3.02, height: 68.84 in. ±3.75, weight: 167.89 ±31.29 lbs.) participated in the inter-session reliability test sessions, while 10 males and 6 females (age: 25.39 ±2.99, height: 69.03 in. ±3.87, weight: 171.61 ±30.54 lbs.) participated in the intra-session inter-rater reliability test session. Two raters (A & B) were involved in this study. Both raters were graduate students in Human Movement Sciences and Certified Strength and Conditioning Specialists (CSCS). Additionally, Rater A held

certifications as an athletic trainer (AT) and was a Functional Movement Screen Certified Specialist. **Intervention:** A two-way mixed effects model of intra-class correlation coefficients ($ICC_{3,1}$) was used to determine the reliability of the inter-session scoring of the FMS and the intra-session inter-rater scoring of the FMS. The FMS includes seven tests: Deep Squat (DS), Hurdle Step (HS), Inline Lunge (IL), Shoulder Mobility (SM), Active Straight Leg Raise (ASLR), Trunk Stability Push up (TSPU), and Rotary Stability (RS). Researchers analyzed the data via intra-class correlation (ICC). The researchers interpreted the ICCs according to the criteria: high reliability, 0.90-0.99; good reliability, 0.80-0.89; fair reliability, 0.70-0.79; poor reliability, 0.60-0.69. **Main outcome measure(s):** The dependent variables were FMS total score, (0-21 scale) and associated tests: Deep Squat (DS), Hurdle Step (HS), Inline Lunge (IL), Shoulder Mobility (SM), Active Straight Leg Raise (ASLR), Trunk Stability Push Up (TSPU), Rotary Stability (RS). **Results:** Inter-session reliability (ICC, SEM): FMS total score (.92,.50), DS (.70,.21), HS (.17,.27), IL (.70,.26), SM (.89,.22), ASLR (.77,.27), TSPU (.87,.27), and RS (each component variable has zero variance). Intra-session inter-rater reliability (ICC, SEM): FMS total score (.98,.25), DS (1.0,.00), HS (.38,.26), IL (.88,.17), SM (.93,.17), ASLR (.92,.17), TSPU (.85,.24), and RS (each component variable has zero variance). **Conclusion:** The FMS total scores displayed high inter-session and inter-rater reliability. Furthermore, with the exception of HS all of the individual tasks displayed good to high inter-rater reliability and fair to high inter-session reliability. While it appears that the FMS is a reliable instrument researchers should direct future studies at investigating its validity in assessing flexibility, mobility, and stability.
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## Free Communications, Poster Presentations: Student Exchange Abstracts

Friday, June 25, 2010, 1:00PM-5:00PM, Grand Hall, authors present 4:00PM-5:00PM

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